

Daily report

04-05-2020

Analysis and prediction of COVID-19 for EU-EFTA-UK and other countries

Foreword

The present report aims to provide a comprehensive picture of the **pandemic situation of COVID-19** in the EU countries, and to be able to foresee the situation in the next coming days.

We employ an **empirical model**, verified with the evolution of the number of confirmed cases in previous countries where the epidemic is close to conclude, including all provinces of China. The model does not pretend to interpret the causes of the evolution of the cases but to permit the **evaluation of the quality of control measures made in each state** and a **short-term prediction of trends**. Note, however, that the effects of the measures' control that start on a given day are not observed until approximately 7-10 days later.

The model and predictions are based on two parameters that are daily fitted to available data:

- ✓ α : the velocity at which spreading specific rate slows down; the higher the value, the better the control.
- ✓ K : the final number of expected cumulated cases, which cannot be evaluated at the initial stages because growth is still exponential.

We show an individual report with 8 graphs and a table with the **short-term predictions** for different countries and regions. We are adjusting the model to **countries and regions** with at least 4 days with more than 100 confirmed cases and a current load over 200 cases. The **predicted period** of a country depends on the number of datapoints over this 100 cases threshold, and is of 5 days for those that have reported more than 100 cumulated cases for 10 consecutive days or more. For short-term predictions, we assign higher weight to last 3 points in the fittings, so that changes are rapidly captured by the model. The whole methodology employed in the inform is explained in the last pages of this document.

In addition to the individual reports, the reader will find an initial dashboard with a brief analysis of the situation in EU-EFTA-UK countries, some summary figures and tables as well as **long-term predictions** for some of them, when possible. These long-term predictions are evaluated without different weights to datapoints. We also discuss a specific issue every day.

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(0) Executive summary – Dashboard

Global EU+EFTA+UK trends and needs

EU+EFTA+UK is almost to reach 1.2M cases. This threshold will probably be overcome tomorrow. Current cumulative incidence is 226 cases per 10^5 inhabitants, and spreading rate remains under 1. **We have descended the 15,000 new cases peak and are hopefully moving towards the 10,000 one.**

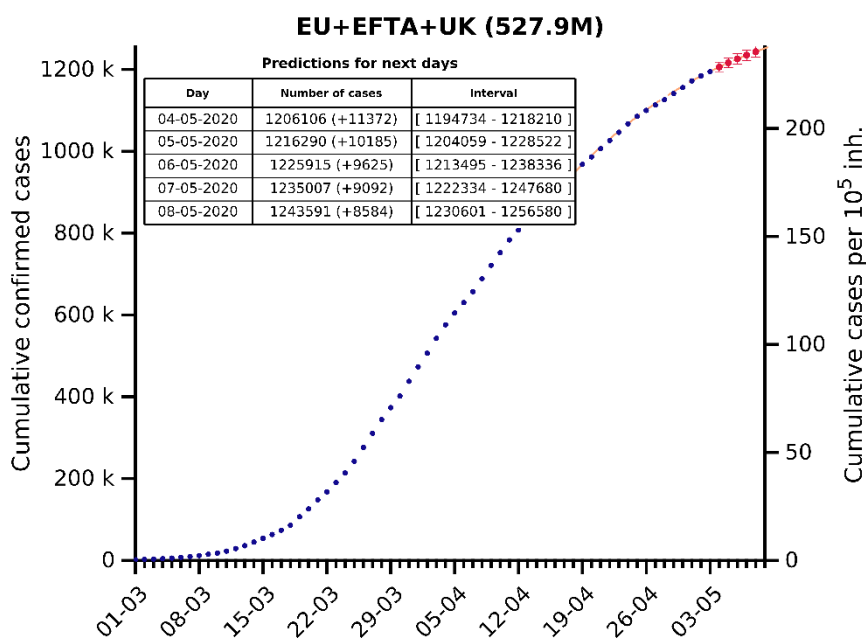
Final expected number of cases is also converging towards a value just beneath 1.5M, around 284 cases per 10^5 inhabitants. Thus, current incidence would be almost 80 % of the final one. All these predictions are reliable as soon as no secondary outbreaks are triggered at short term, given the deconfinement processes that are being implemented by the countries.

Looking at **risk diagrams** (Appendix 2), we see that there are two countries that have stuck at intermediate-high risk zone: Sweden and United Kingdom. On the contrary, the number of countries that have transited from red zones (high risk) to green ones (low risk) is increasing. We can find Austria, Switzerland, Germany and Iceland, among them. Finally, we observe some countries that are in the middle of its way to the green zone, still at intermediate or intermediate-high risk but with good perspectives if current trend is maintained (e.g. Italy, France, Belgium, among others).

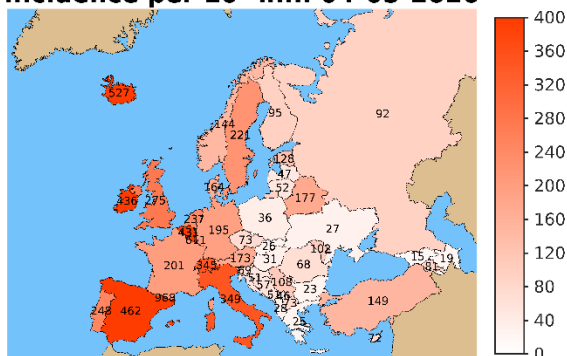
The analysis section discusses reliability of long-term predictions for cumulative cases and deaths, and presents the results for most affected countries.

Trends for specific countries

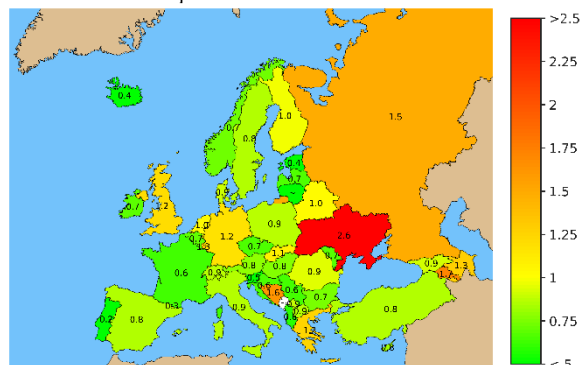
Beyond daily fluctuations (see current ρ in the map), most of countries have a ρ_7 (7-day moving average of ρ) below 1. The two exceptions are **United Kingdom** (1.05) and **Cyprus** (1.08). Nevertheless, there are still a few countries with ρ_7 close to 1: **Sweden**, 0.92; **Austria**, 0.91; **Poland**, 0.92; **Romania**, 0.91; **Bulgaria**, 0.91. Among them, only **Sweden** has a 14-day attack rate that, in combination with this ρ_7 , situates the country at intermediate risk. Looking at estimated index EPG_{EST} , countries at highest real risk would be **United Kingdom** and **Sweden**.



Incidence per 10^5 inh. 04-05-2020



ρ 03-05-2020



Situation and trends per country

Table of current situation in EU countries. Colour scale is relative except when indicated, this means that it is applied independently to each column, and distinguishes best (green) from worst (red) situations according to each of the variables. **New!** Last column (EPG_{EST}) indicates EPG assessed with **estimated real 14-day attack rate** (see report from 22/04 for details). EPG_{REP} is calculated with **data reported by countries**. EPG_{REP} and EPG_{EST} **cannot be compared between them** because scales are different, but can be independently used for estimating risk of countries according to reported or estimated real situation, respectively.

Country	Reported data						Indexes		
	Cumulative cases	Attack rate /10 ⁵ inh.	Cumulative deaths	Mortality /10 ⁵ inh.	Active cases (last 14 days)	14-day attack rate /10 ⁵ inh.	$\rho_7^{(1)}$	$EPG_{REP}^{(2)}$	$EPG_{EST}^{(3)}$
Spain	217,466	469.2	25,264	54.5	28,888	62.3	0.68	42	494
Italy	210,717	354.6	28,884	48.6	31,745	53.4	0.77	41	580
United Kingdom	186,599	280.9	28,446	42.8	66,532	100.1	1.05	105	1,772
Germany	163,175	199.2	6,692	8.2	21,503	26.3	0.72	19	86
France	131,287	202.9	24,895	38.5	18,681	28.9	0.68	20	380
Belgium	49,906	439.4	7,844	69.1	11,410	100.5	0.62	63	1,042
Netherlands	40,571	238.8	5,056	29.8	7,916	46.6	0.67	31	408
Switzerland	29,822	348.0	1,472	17.2	2,164	25.3	0.75	19	100
Portugal	25,282	243.8	1,043	10.1	5,076	48.9	0.57	28	122
Sweden	22,317	226.8	2,679	27.2	7,932	80.6	0.92	75	1,220
Ireland	21,506	455.1	1,303	27.6	6,255	132.4	0.65	86	600
Austria	15,597	179.0	598	6.9	887	10.2	0.91	9	36
Poland	13,693	35.8	678	1.8	4,406	11.5	0.92	11	66
Romania	13,163	66.6	780	3.9	4,417	22.3	0.91	20	141
Denmark	9,523	166.7	484	8.5	2,139	37.4	0.86	32	173
Norway	7,809	145.5	208	3.9	741	13.8	0.74	10	29
Czech Republic	7,781	73.3	248	2.3	994	9.4	0.80	8	26
Finland	5,254	95.5	230	4.2	1,471	26.7	0.88	24	124
Luxembourg	3,824	663.9	96	16.7	274	47.6	0.83	40	NA
Hungary	3,035	31.1	351	3.6	1,051	10.8	0.87	9	131
Greece	2,626	23.5	144	1.3	391	3.5	0.76	3	16
Croatia	2,096	49.8	79	1.9	225	5.3	0.55	3	NA
Iceland	1,799	493.9	10	2.7	28	7.7	0.53	4	NA
Estonia	1,700	129.6	55	4.2	172	13.1	0.67	9	NA
Bulgaria	1,618	22.7	73	1.0	703	9.9	0.91	9	NA
Slovenia	1,439	69.2	96	4.6	109	5.2	0.69	4	NA
Lithuania	1,410	48.5	46	1.6	84	2.9	NA	NA	NA
Slovakia	1,408	25.9	24	0.4	247	4.5	0.39	2	NA
Latvia	879	44.6	16	0.8	152	7.7	0.87	7	NA
Cyprus	872	74.5	20	1.7	105	9.0	1.08	10	NA
Malta	477	111.2	4	0.9	50	11.7	NA	NA	NA
Liechtenstein	83	215.3	1	2.6	1	2.6	NA	NA	NA

Scale									
Worst	Worst	Worst	Worst	Worst	Worst	Worst	2.0	200	2000
Best	Best	Best	Best	Best	Best	Best	0.0	0	0

⁽¹⁾ ρ_3 is the average of 7 consecutive ρ , but can still fluctuate. ⁽²⁾ EPG stands for Effective Growth Potential. EPG_{REP} is obtained by multiplying attack rate of last 14 days per 10⁵ inhabitants (i.e. density of cases) by ρ_3 (a value related with effective reproduction number and that, therefore, determines the dynamics for subsequent days). EPG_{EST} is obtained by multiplying estimated real attack rate of last 14 days per 10⁵ inhabitants by ρ_3 .

Highlights for countries with highest number of reported cases

- ✓ Spain's predictions are better than Italy's ones. Spain could be below the level of 1,000 new cases the next days, while Italy would remain at around 1,400. United Kingdom keeps stuck at the level of 4,500-5,000, while predictions for France and Germany are similar (around 600-800 cases).
- ✓ Spreading rate ρ_7 is 1 for UK, 0.8 for Italy, and 0.7 for France, Spain and Germany.

Time indicators by country

This table summarizes a few time indicators for each country: time since 50 cases were reported, time interval between an attack rate of $1/10^5$ inhabitants and an attack rate of $10/10^5$ inhabitants, and time interval between attack rates of 10 to 100 per 10^5 inhabitants (only for countries that have overtaken this threshold).

Countries	Days since the first 50 cases	Time interval between 1 and 10 cases / 10^5 inh. (days)	Time interval between 10 and 100 cases / 10^5 inh. (days)
Italy	72	11	16
France	66	10	20
Germany	66	12	17
Spain	64	7	12
United Kingdom	62	11	19
Norway	61	9	24
Switzerland	61	9	12
Netherlands	60	11	20
Sweden	60	10	28
Austria	59	10	14
Belgium	59	11	14
Greece	58	18	ND
Iceland	58	5	15
Denmark	56	4	30
Czech Republic	55	11	ND
Finland	54	12	ND
Portugal	54	9	15
Slovenia	54	6	ND
Ireland	53	8	18
Romania	53	15	ND
Estonia	52	5	30
Poland	52	17	ND
Bulgaria	50	24	ND
Luxembourg	50	6	7
Slovakia	50	24	ND
Croatia	49	12	ND
Latvia	48	12	ND
Cyprus	47	12	ND
Hungary	47	20	ND
Malta	46	8	34
Lithuania	45	9	ND
Liechtenstein	40	9	11

Analysis: Predicting final incidence and case fatality rate.

Gompertz-curve based predictions become more and more robust as the epidemic progresses until countries enter the final long tail, where Gompertz fails. At this moment, most European countries have overcome the peak but have not fully reached the end stages of the long tail. Therefore, predictions made with Gompertz fittings should be highly confident these weeks, as soon as the release of control measures do not cause secondary outbreaks.

Gompertz curve can be fit to the cumulative series provided by different countries, i.e., cumulative cases but also cumulative cases, hospitalizations, ICUs, and deaths. In this analysis, we discuss long term predictions on cumulative cases and deaths. We have chosen those countries with more than 300 reported deaths, and with a current cumulative number of cases higher than 50 % of the expected final number. **Note that, as a disclaimer, any of the results shown in this Analysis are only valid if current trends are maintained. If deconfinement processes change the countries' dynamics and secondary outbreaks are triggered, these predictions will not be valid.**

The prediction of the **expected final incidence** is given by parameter K_{cases} . When we look at the evolution of this prediction with time, we see that it is clearly **converging towards a given value for most countries**. In fact, we have seen that the predictions show reasonably low uncertainty when the cumulative number of cases reaches 70 % of K_{cases} . The next table shows the values of the expected final number of cases (K_{cases}), together with absolute error (σ_{cases}). We also show the final expected incidence (K_{cases} per 10^5 inh.), and the percentage from the final expected value at which the country currently is.

Country	Cumulative cases	Attack rate per 10^5 inh.	K_{cases}	σ_{cases}	K_{cases} per 10^5 inh.	Current %K
Italy	209328	352	233705	2184	393.2	90%
United Kingdom*	182260	274	311045	10371	468.2	59%
Spain	216582	467	241726	4631	521.5	90%
France	130979	202	158766	4206	245.3	82%
Belgium	49517	436	68156	1799	600.1	73%
Germany	162496	198	190070	4786	232.0	85%
Netherlands	40236	237	51242	719	301.7	79%
Sweden*	22082	224	42375	1135	430.7	52%
Switzerland	29734	347	32011	526	373.5	93%
Portugal	25190	243	28393	309	273.7	89%
Romania*	12732	64	18894	378	95.5	67%
Poland	13375	35	19096	295	50.0	70%
Austria	15558	179	16000	248	183.7	97%
Denmark	9407	165	11451	410	200.5	82%
Hungary*	2998	31	4695	203	48.1	64%

* Countries with current number of cumulative cases lower than 70 % of K_{cases} still have high uncertainty in estimated K_{cases} . These estimated K values are expected to significantly decrease subsequent days.

We have fitted the Gompertz curve to cumulative deaths as well. Next, we show a table with the estimated final number of deaths, K_{deaths} , as well as the error in these estimates, σ_{cases} , and estimated K_{deaths} per 10^5 inhabitants. It is important to keep in mind that **Belgium is overreporting mortality**, since they include suspicious cases without a test validation. Therefore, its final situation regarding deaths cannot be compared with other countries. We have also evaluated the expected case fatality rate, which is strongly affected by

the diagnosis rate of each country. Finally, we also show the percentage from final expected value at which the country currently is. In this regard, note that the United Kingdom and Sweden (highlighted in italic in the table) have currently estimated % K_{deaths} higher than current estimated % K_{cases} . This makes no sense from the epidemiological point of view. In fact, they are still below 70% K_{cases} . Therefore, it is expected that K_{cases} will still significantly decrease during the next days, when these countries manage to overcome the peak in new cases. Then, this percentage will probably increase (i.e., if K_{cases} decreases, they will be closer to that final value).

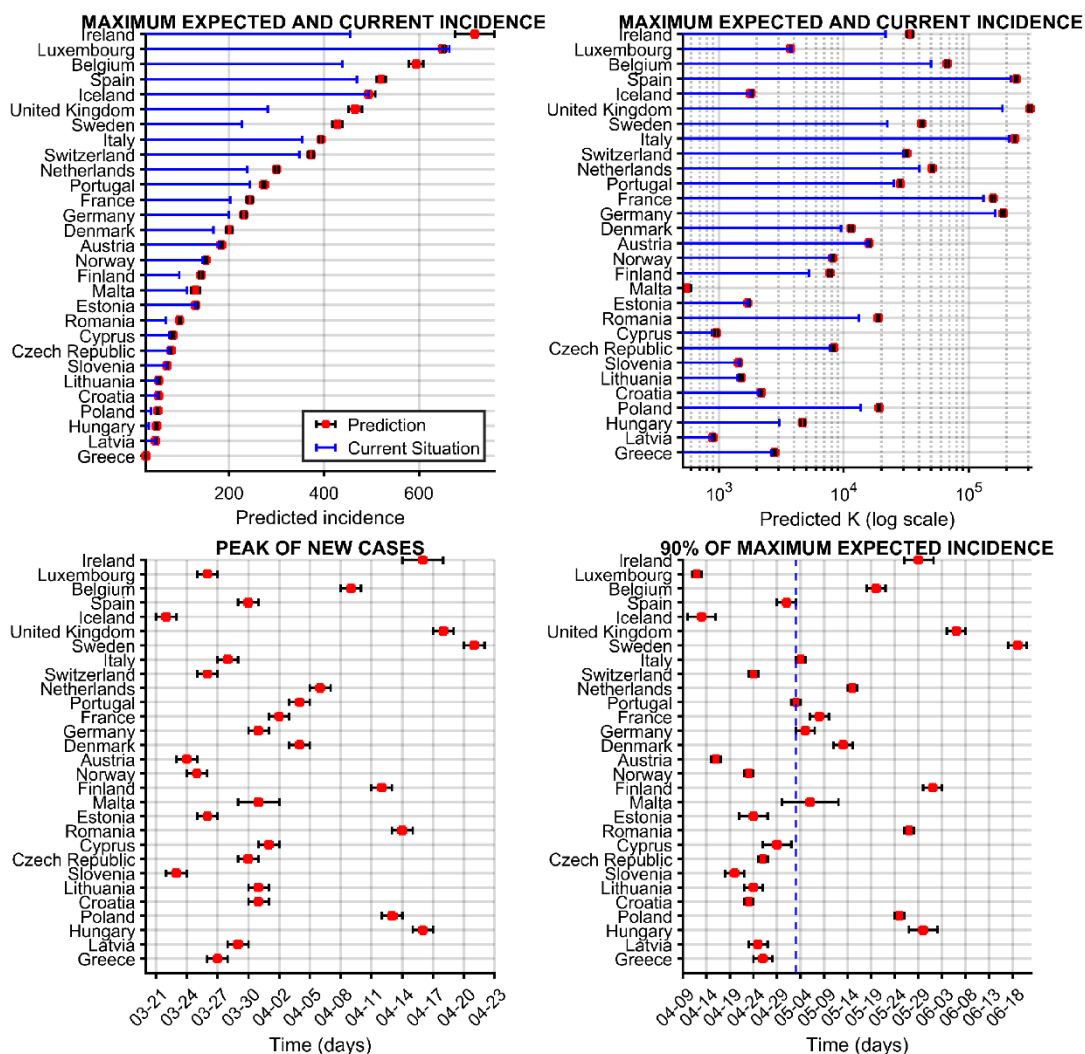
Country	Cumulative deaths	Mortality per 10^5 inh.	K_{deaths}	σ_{deaths}	K_{deaths} per 10^5 inh.	Expected final CFR	Current % K_{deaths}
Italy	28710	48.3	33432	423	56.3	14%	86%
<i>United Kingdom</i>	28131	42.3	39932	1012	60.1	13%	70%
Spain	25100	54.2	27778	257	59.9	11%	90%
France	24760	38.3	34248	1870	52.9	22%	72%
Belgium	7765	68.4	10293	336	90.6	15%	75%
Germany	6649	8.1	9546	216	11.7	5%	70%
Netherlands	4987	29.4	5764	84	33.9	11%	87%
<i>Sweden*</i>	2669	27.1	4561	255	46.4	11%	59%
Switzerland	1466	17.1	1778	37	20.7	6%	82%
Portugal	1023	9.9	1225	29	11.8	4%	84%
Romania	771	3.9	1022	64	5.2	5%	75%
Poland*	664	1.7	1245	79	3.3	7%	53%
Austria	596	6.8	666	13	7.6	4%	89%
Denmark	475	8.3	527	8	9.2	5%	90%
Hungary*	340	3.5	632	51	6.5	13%	54%

* Countries with current number of cumulative deaths lower than 70 % of K_{deaths} still have high uncertainty in estimated K_{deaths} . These estimated K values are expected to significantly decrease subsequent days.

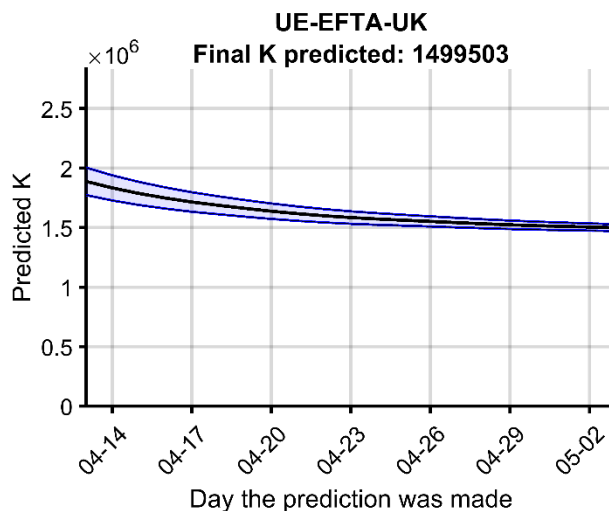
In all cases, the natural tendency of estimated K is to decrease with time. As mentioned above, this decrease is significant until the level of 70 % K is achieved. Then, the convergence is smoother. Therefore, all the estimates shown in the table can be considered an upper bound, rather than a precise value, but they provide an idea of which the evolution of the country is.

Long-term predictions

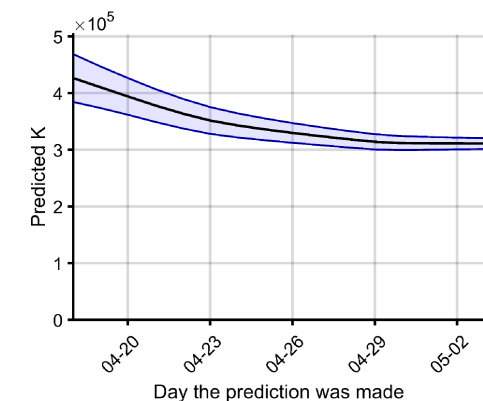
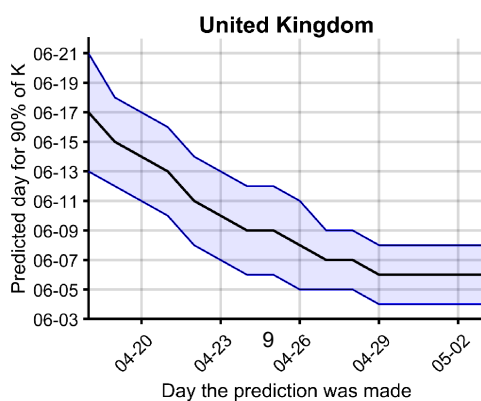
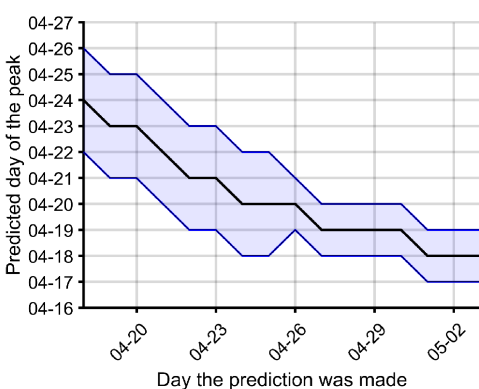
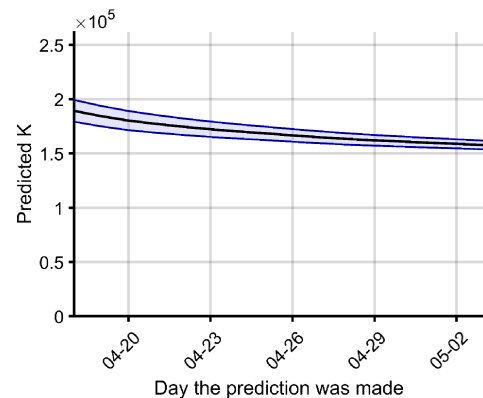
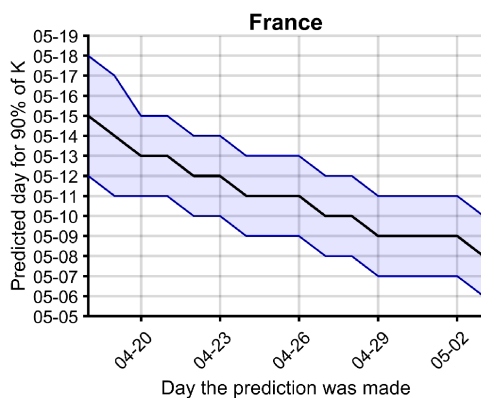
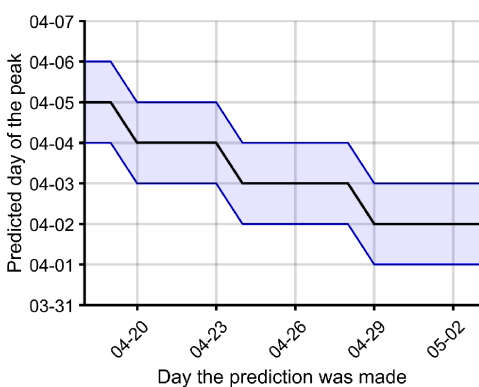
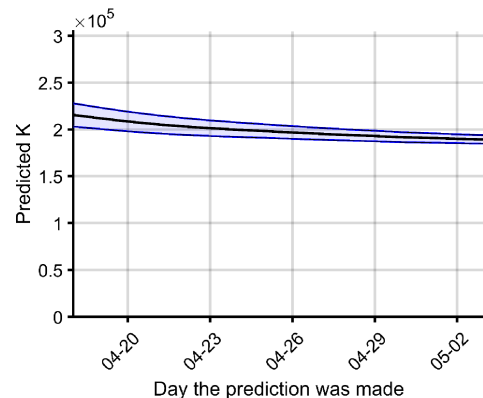
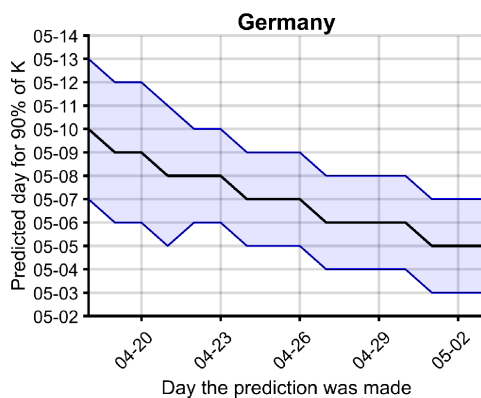
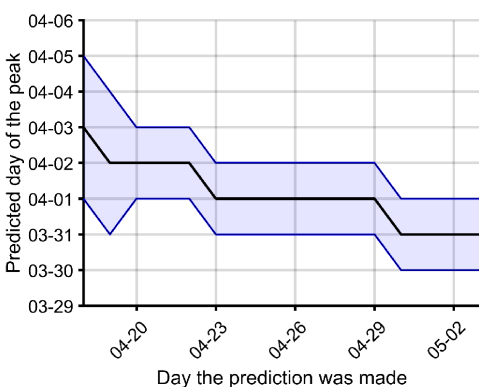
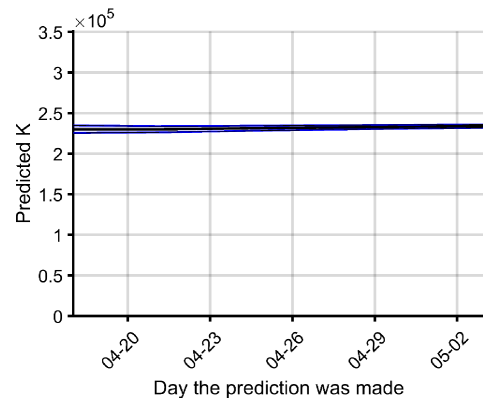
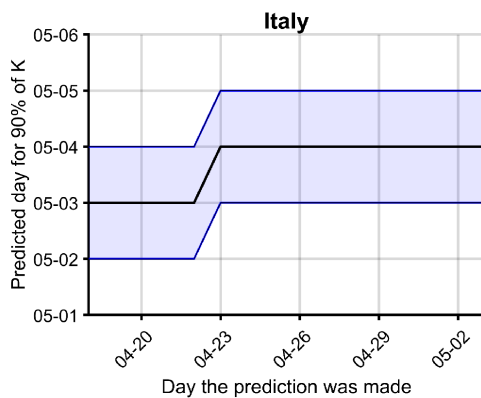
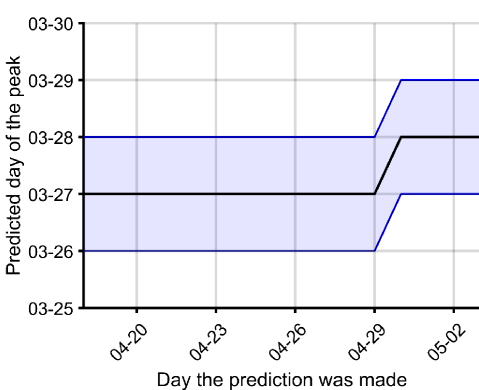
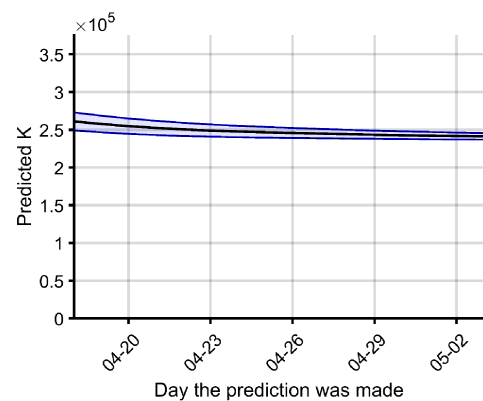
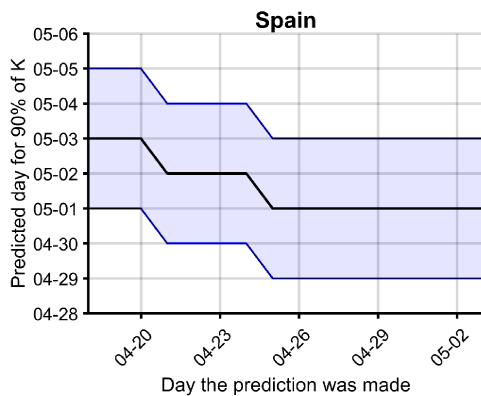
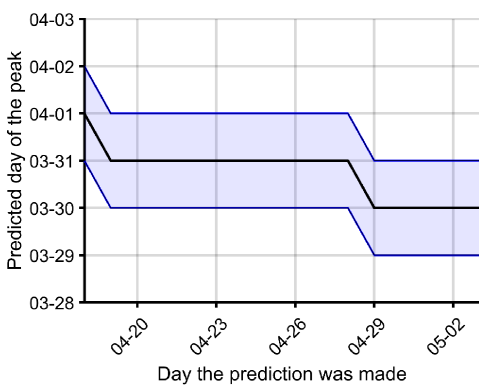
Long-term predictions, evaluated with the **whole historical series** and without weighting last 3 points. Up-left: Predictions of maximum incidences per country (total final expected attack rate per 10^5 inh.). Up-right: Predictions of maximum absolute number of cases per country (K, in log scale). Blue lines indicate current situation. Bottom-left: Time in which peak in new cases was achieved / will be achieved. Bottom-right: Time at which 90 % of K was achieved / will be achieved. Blue dotted line indicates current date.



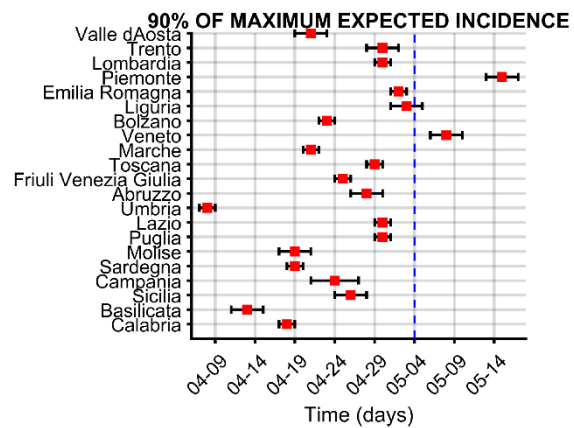
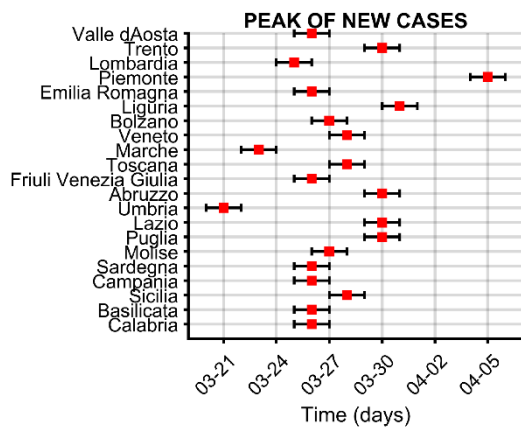
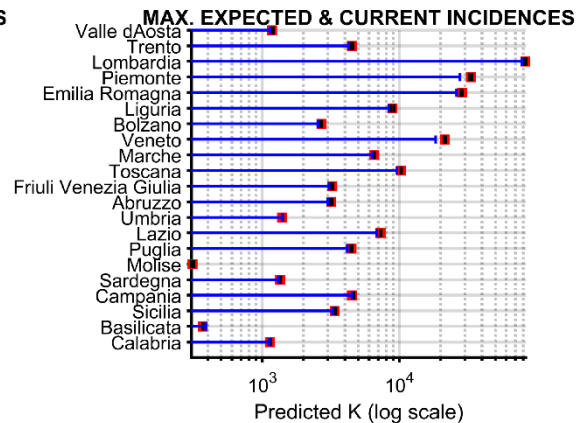
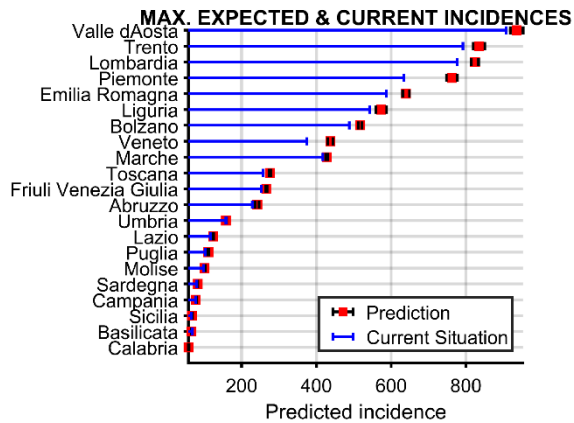
Final expected K for UE+EFTA+UK. Evolution of predicted K with time, where convergence to best estimate is seen. Last prediction is numerically shown in title.



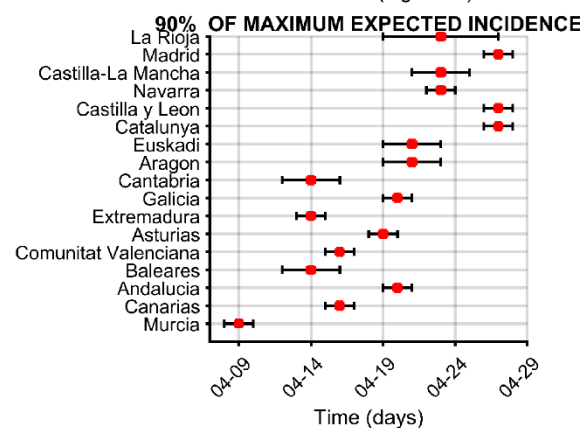
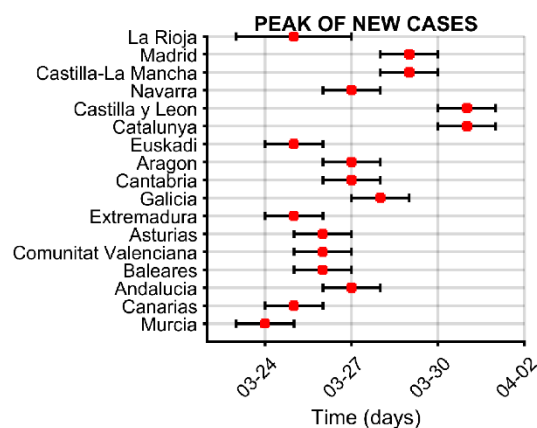
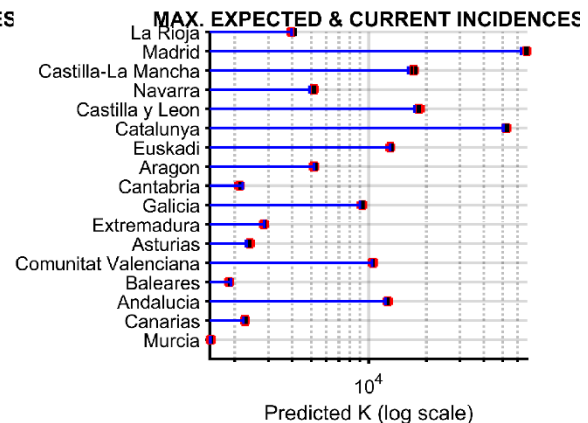
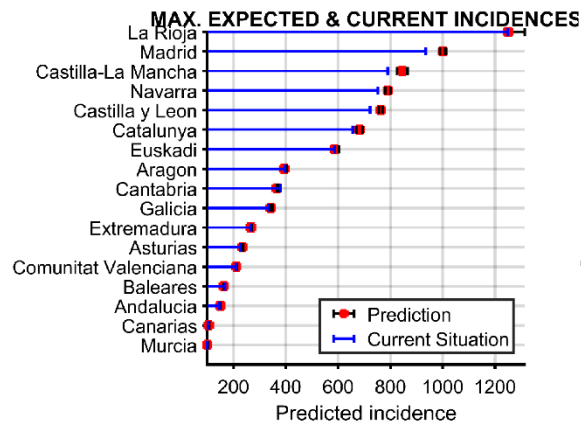
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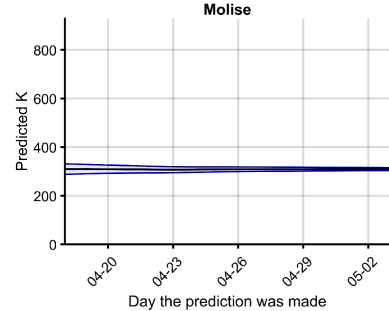
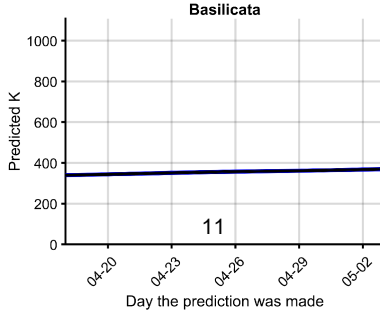
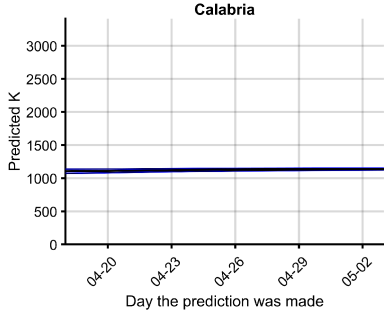
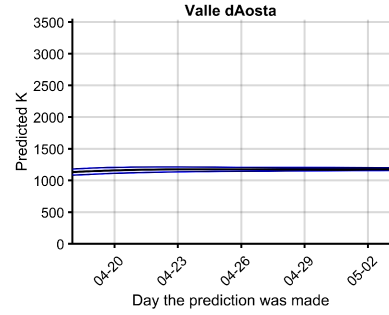
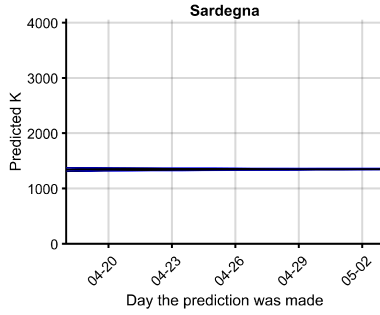
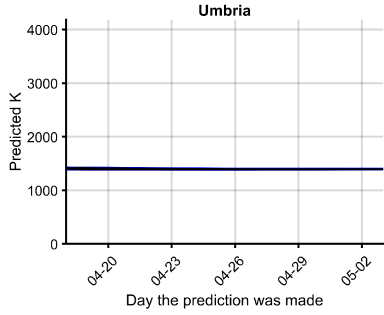
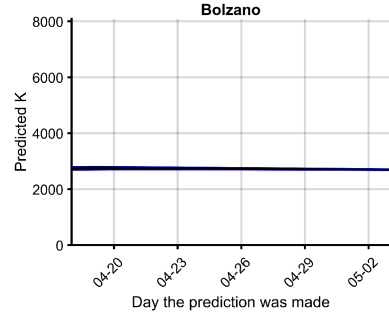
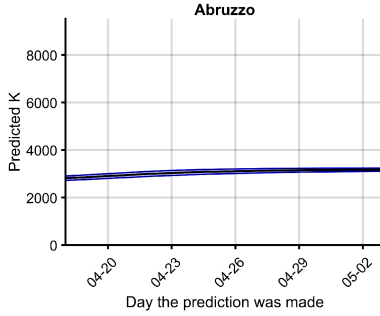
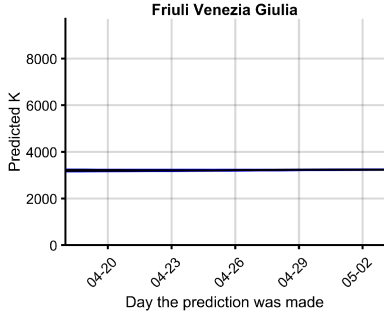
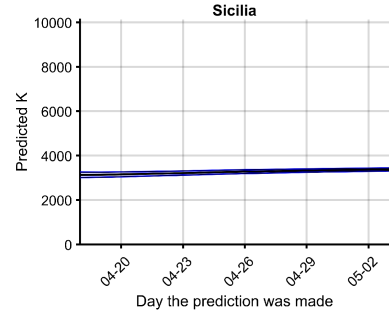
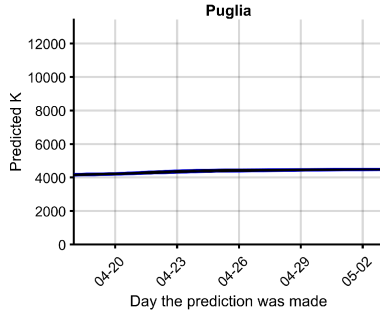
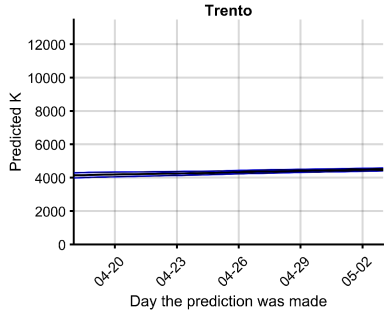
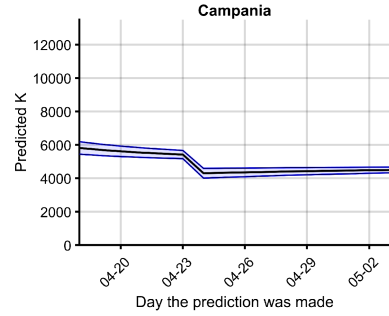
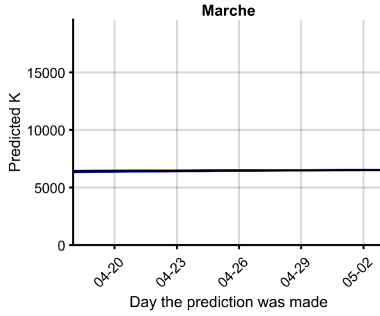
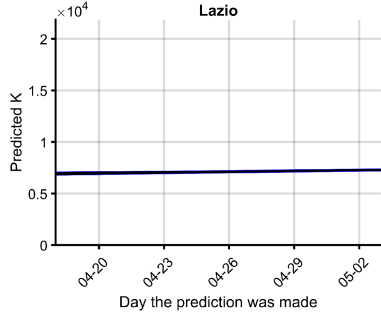
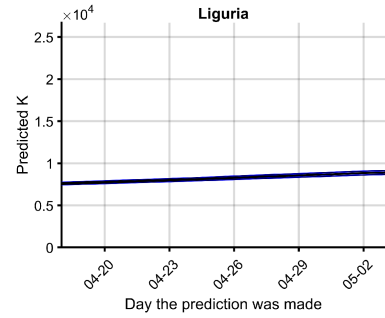
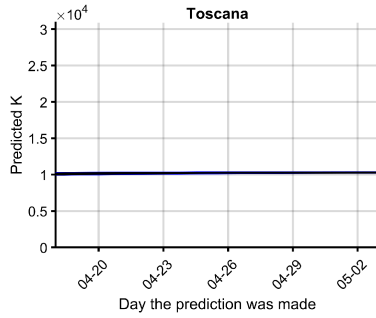
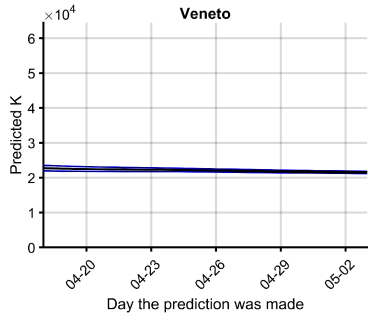
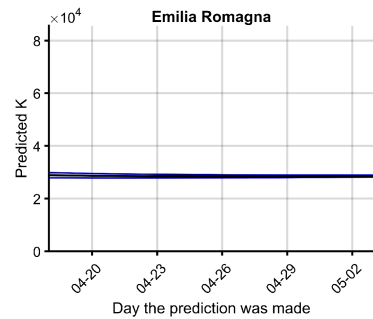
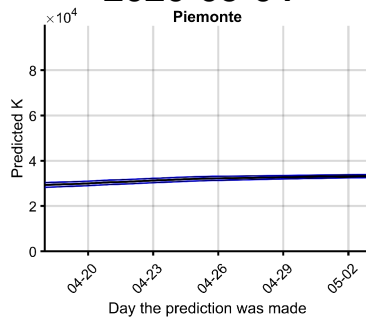
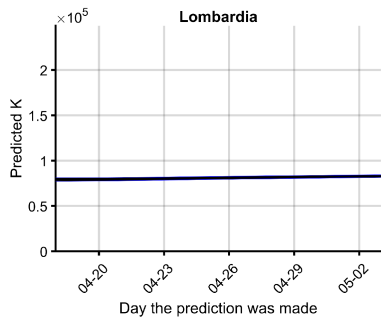
Italian regions



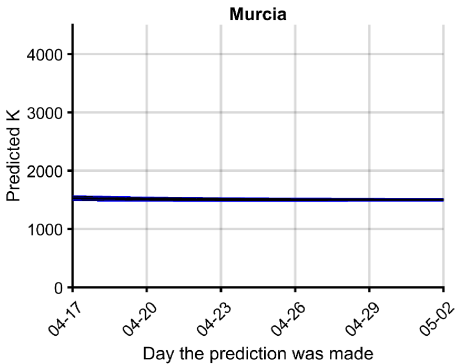
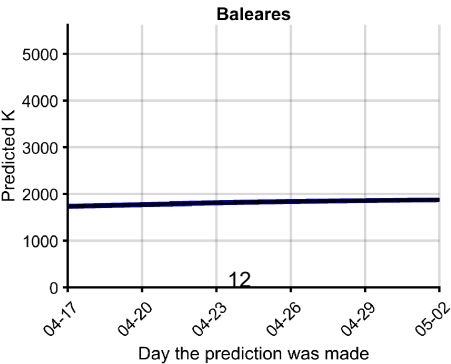
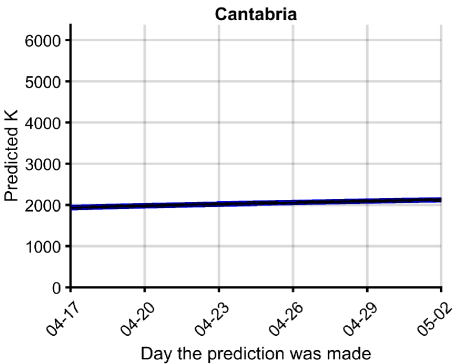
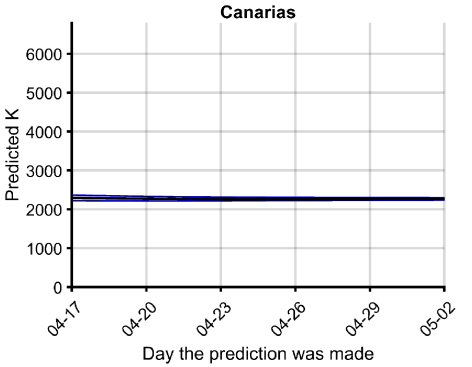
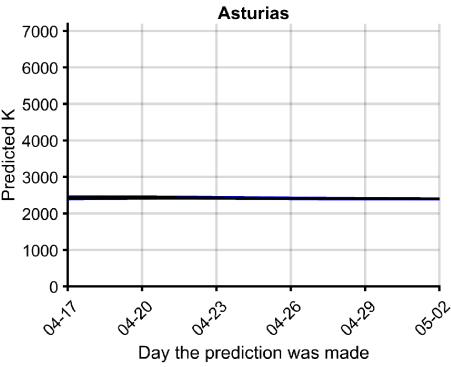
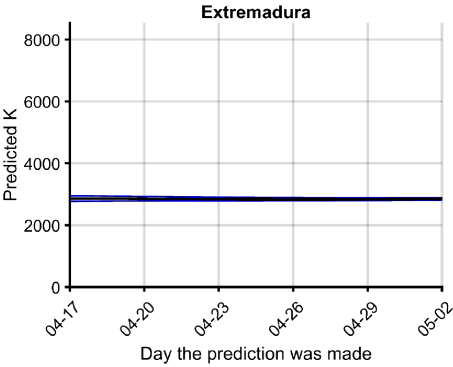
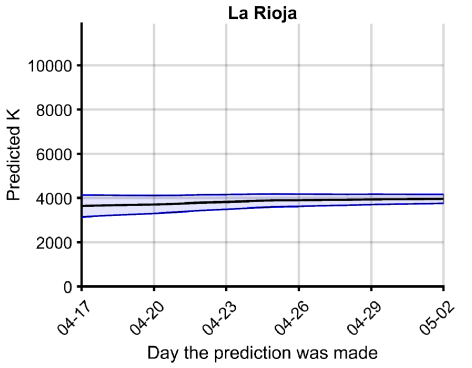
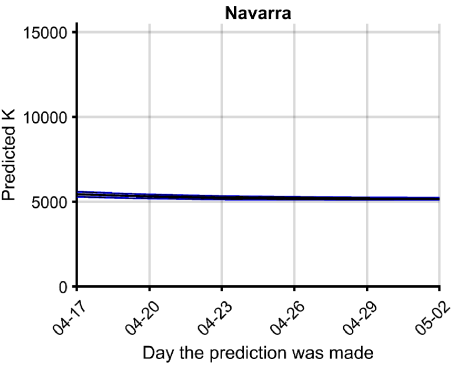
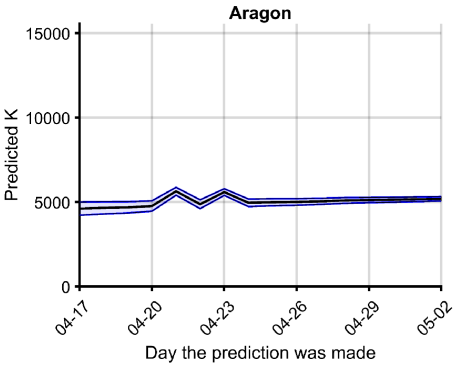
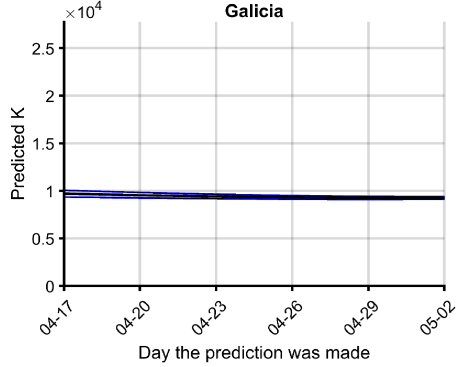
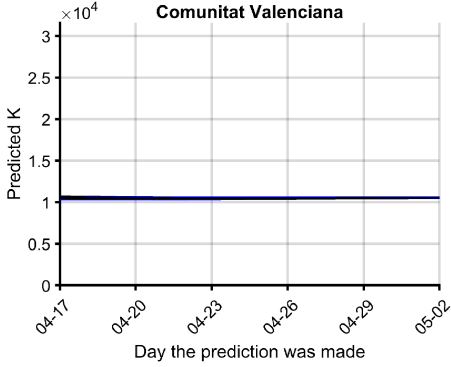
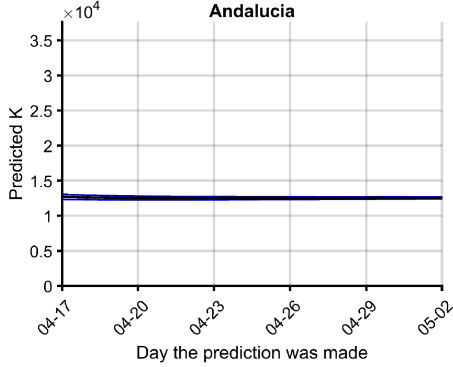
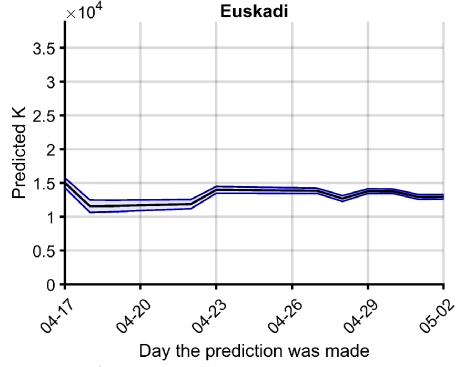
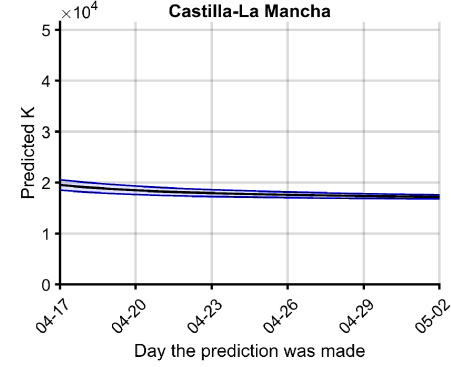
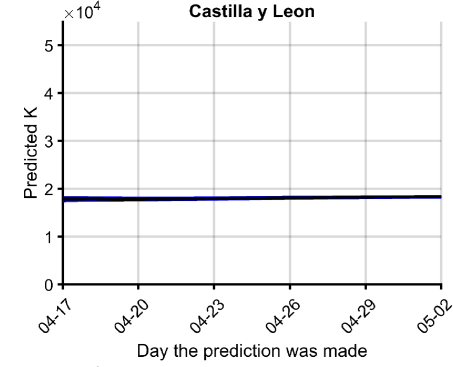
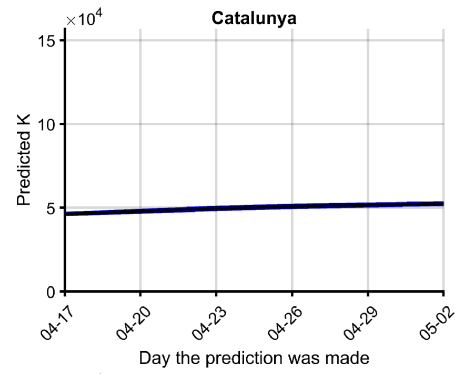
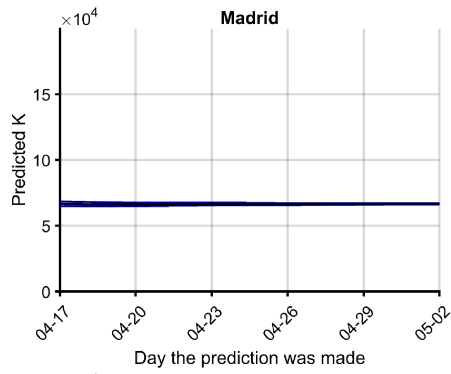
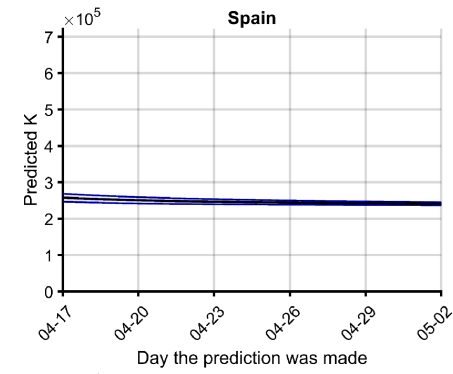
Spanish regions



2020-05-04



2020-05-03



Situation and trends in Italian and Spanish regions

Italy

Country	Reported data						Indexes		
	Cumulative cases	Attack rate / 10 ⁵ inh.	Cumulative deaths	Mortality / 10 ⁵ inh.	Active cases (last 14 days)	14-day attack rate / 10 ⁵ inh.	$\rho_7^{(1)}$	EPG _{REP} ⁽²⁾	EPG _{EST} ⁽³⁾
Lombardia	78,105	777.8	14,294	142.3	11,134	110.9	0.76	84	1,570
Piemonte	27,622	634.1	3,186	73.1	6,273	144.0	0.80	116	1,378
Emilia Romagna	26,175	587.0	3,666	82.2	3,308	74.2	0.88	65	952
Veneto	18,373	374.5	1,528	31.1	2,246	45.8	0.73	34	292
Toscana	9,601	257.4	881	23.6	1,094	29.3	0.75	22	219
Liguria	8,412	542.5	1,221	78.7	1,743	112.4	0.90	102	1,568
Lazio	6,847	116.5	524	8.9	1,032	17.6	0.87	15	120
Marche	6,363	417.2	932	61.1	537	35.2	0.79	28	417
Campania	4,498	77.5	366	6.3	424	7.3	0.65	5	39
Trento	4,258	397.1	430	40.1	668	62.3	0.81	50	1,073
Puglia	4,153	103.1	429	10.6	586	14.5	0.77	11	120
Sicilia	3,255	65.1	244	4.9	496	9.9	0.64	6	49
Friuli Venezia Giulia	3,076	253.1	299	24.6	301	24.8	0.70	17	174
Abruzzo	3,000	228.7	332	25.3	388	29.6	0.64	19	217
Bolzano	2,541	2,365.1	284	264.3	147	136.8	0.59	81	195
Umbria	1,394	158.0	70	7.9	45	5.1	1.24	6	NA
Sardegna	1,317	80.3	119	7.3	89	5.4	0.81	4	42
Valle d'Aosta	1,143	910.0	139	110.7	55	43.8	1.73	76	933
Calabria	1,118	57.4	88	4.5	80	4.1	0.51	2	NA
Basilicata	386	68.6	25	4.4	44	7.8	NA	NA	NA
Molise	301	98.5	22	7.2	20	6.5	0.63	4	NA

Scale								
Worst	Worst	Worst	Worst	Worst	Worst	Worst	2.0	200
Best	Best	Best	Best	Best	Best	Best	0.0	0

Spain

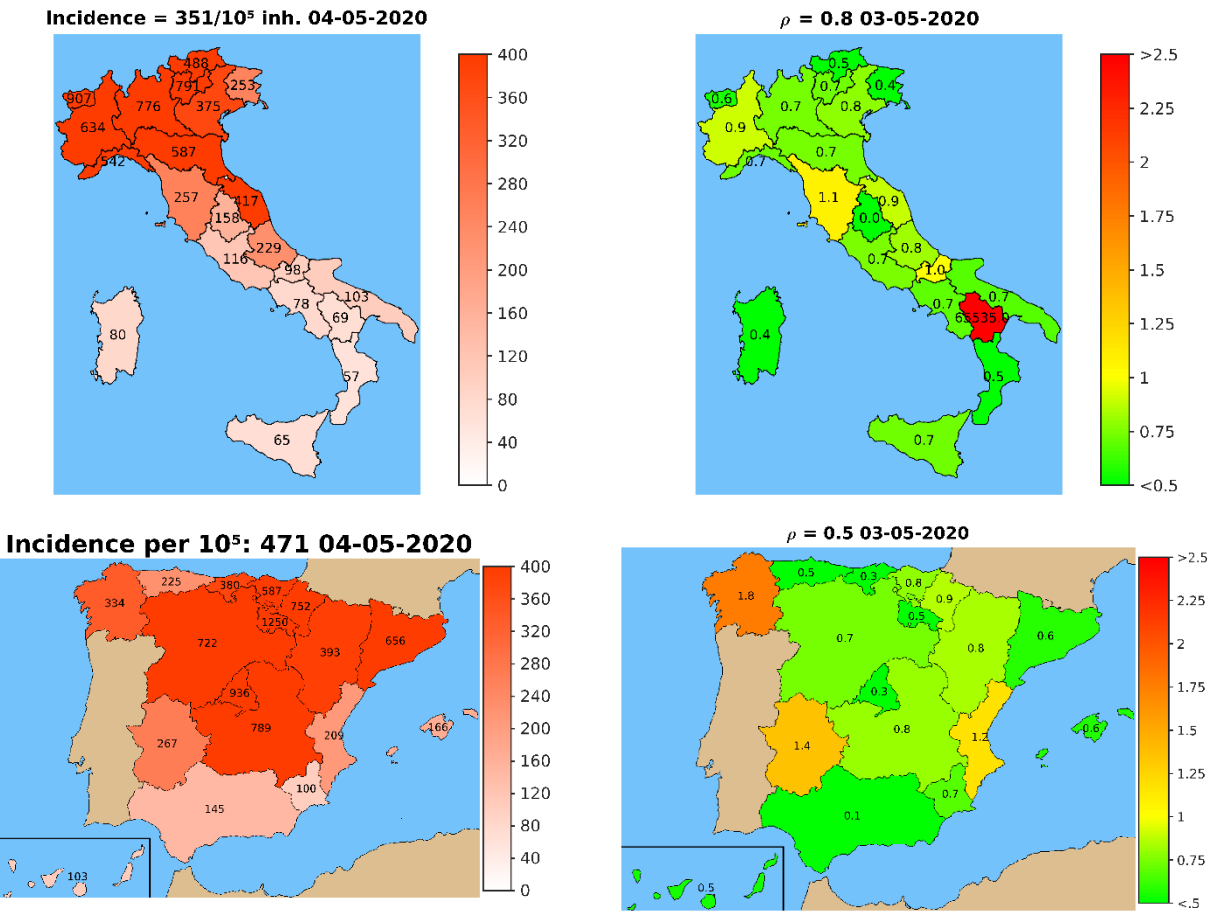
Autonomous regions	Reported data						INAxes		
	Cumulative cases	Attack rate / 10 ⁵ inh.	Cumulative deaths	Mortality rate / 10 ⁵ inh.	Active cases (last 14 days)	14-day attack rate / 10 ⁵ inh.	$\rho_7^{(1)}$	EPG _{REP} ⁽²⁾	EPG _{EST} ⁽³⁾
Madrid	62,395	939.6	8,376	126.1	8,095	121.9	0.73	89	1,189
Catalunya	50,366	665.8	5,220	69.0	8,690	114.9	0.60	69	729
Castilla y Leon	17,334	719.8	1,818	75.5	2,553	106.0	0.66	70	761
Castilla-La Mancha	16,050	788.5	2,590	127.2	1,325	65.1	0.58	38	602
Euskadi	12,952	594.7	1,341	61.6	1,381	63.4	0.66	42	438
ANAAalucia	12,194	144.7	1,263	15.0	1,164	13.8	0.52	7	77
Comunitat Valenciana	10,436	209.8	1,269	25.5	728	14.6	0.72	11	130
Galicia	9,011	333.7	569	21.1	712	26.4	1.37	36	249
Aragon	5,188	392.8	762	57.7	534	40.4	0.7	29	449
Navarra	4,918	756.7	466	71.7	469	72.2	0.8	56	565
La Rioja	3,961	1,263.1	335	106.8	297	94.7	0.47	45	390
Extremadura	2,849	267.4	460	43.2	157	14.7	1.69	25	431
Asturias	2,306	225.6	284	27.8	125	12.2	1.14	14	178
Canarias	2,225	100.8	141	6.4	158	7.2	0.49	4	23
Cantabria	2,206	379.2	197	33.9	233	40.1	0.93	37	357
Baleares	1,908	160.6	197	16.6	159	13.4	0.58	8	84
Murcia	1,492	100.3	134	9.0	52	3.5	0.83	3	26
Melilla	119	140.5	2	2.4	15	17.7	NA	NA	NA
Ceuta	101	119.0	4	4.7	1	1.2	NA	NA	NA

Scale								
Worst	Worst	Worst	Worst	Worst	Worst	Worst	2.0	200
Best	Best	Best	Best	Best	Best	Best	0.0	0

⁽¹⁾ ρ_3 is the average of 7 consecutive ρ , but can still fluctuate. ⁽²⁾ EPG stands for Effective Growth Potential. EPG_{REP} is obtained by multiplying attack rate of last 14 days per 10⁵ inhabitants (i.e. density of cases) by ρ_3 (a value related with effective reproduction number and that, therefore, determines the dynamics for subsequent days). EPG_{EST} is obtained by multiplying estimated real attack rate of last 14 days per 10⁵ inhabitants by ρ_3 .

Maps of Italian and Spanish regions

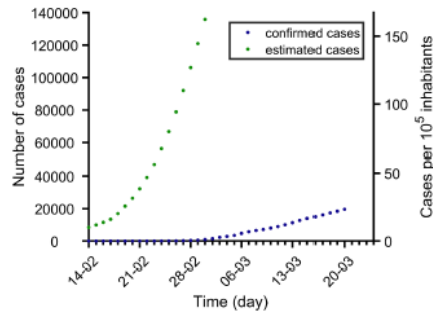
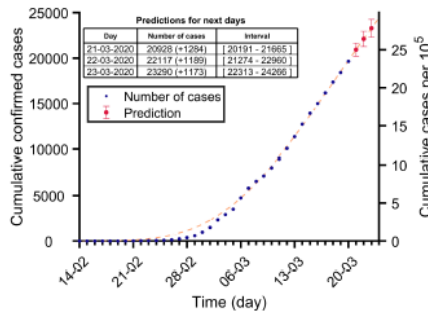
Cumulative incidence and spreading rate (ρ) in Italian and Spanish regions.



Legend: Countries' reports details

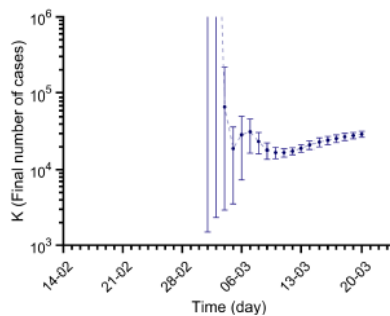
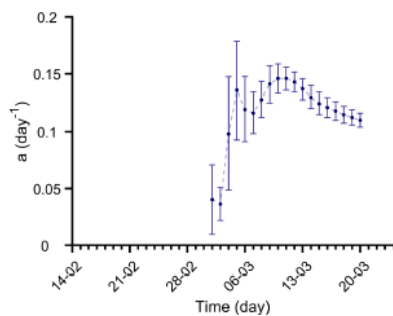
Iran 20-03-2020. Population: 83.7M. Current cumulated incidence: $23/10^5$

Confirmed cases:
data (blue),
model fitted
(dashed line),
predictions (red
points and table)



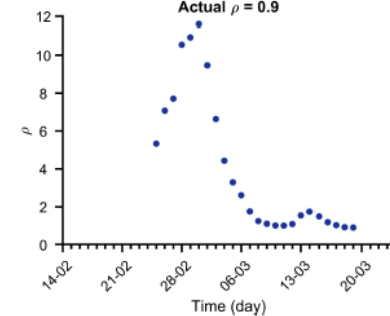
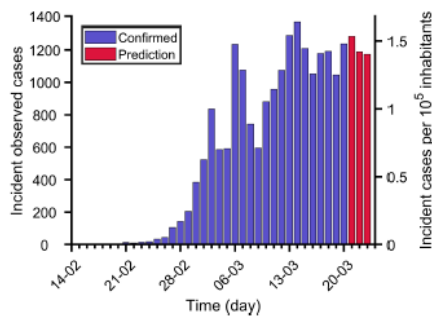
Estimated
cases using
death rate (see
Methods)

Fitted α value
using points
prior to each
date



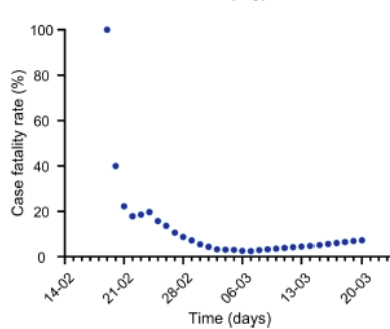
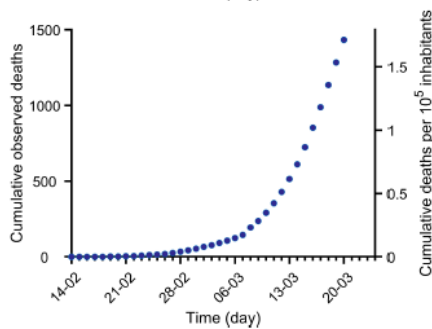
Fitted K value
using points
prior to each
date

Reported
and
predicted
new cases



Evolution of ρ , a
parameter related
with Reproduction
number (see
Methods)

Reported
deaths

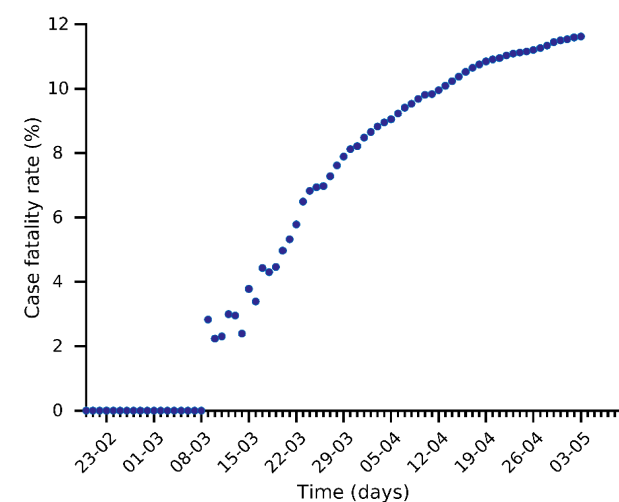
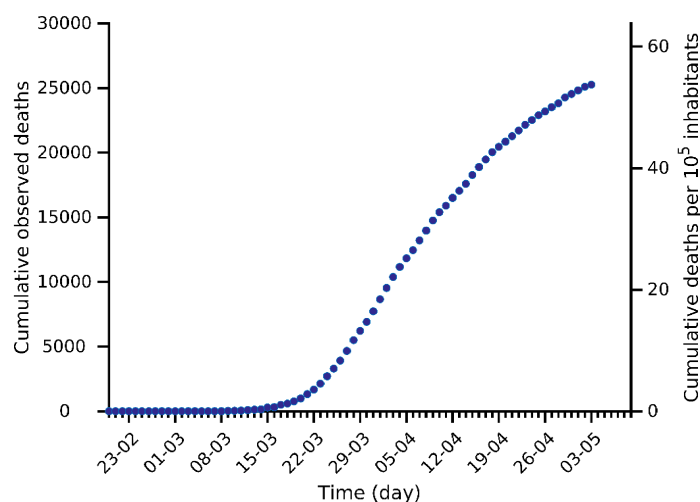
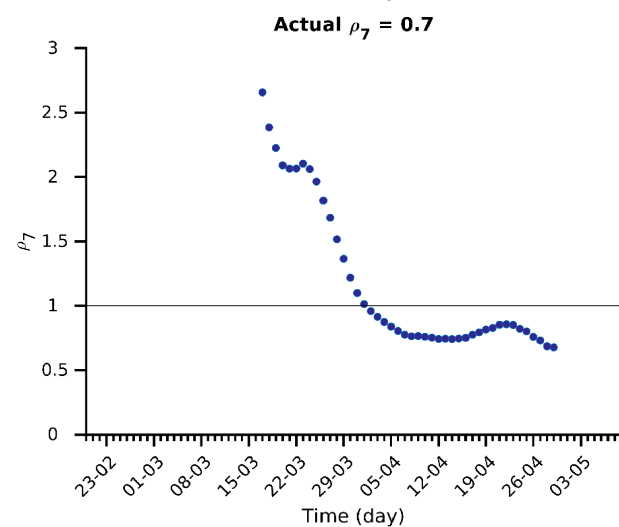
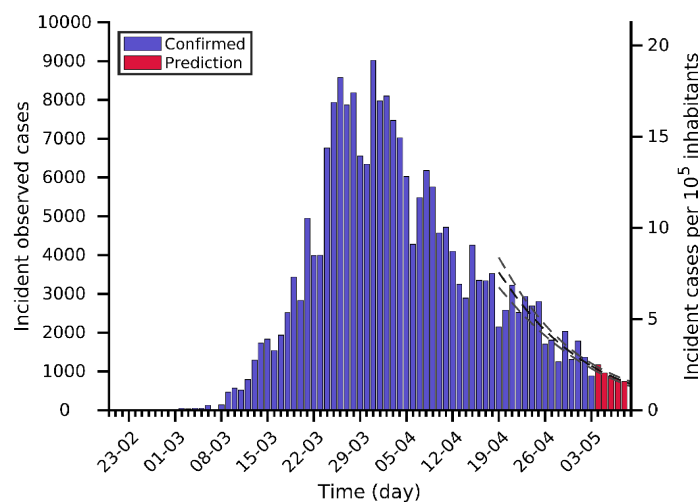
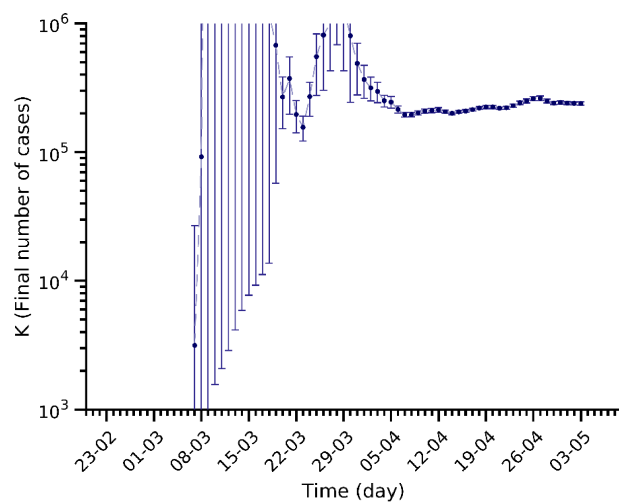
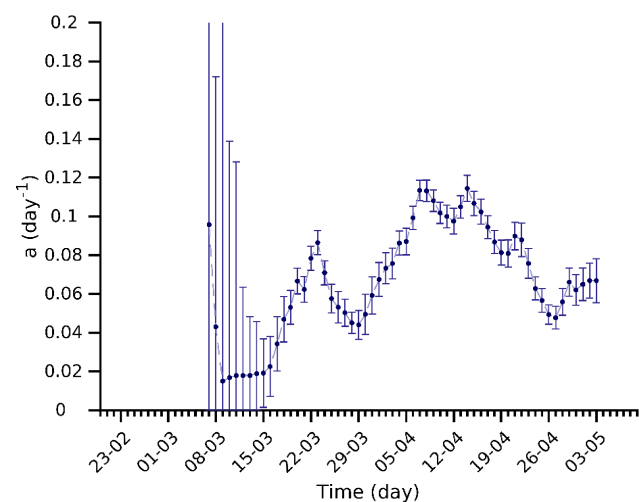
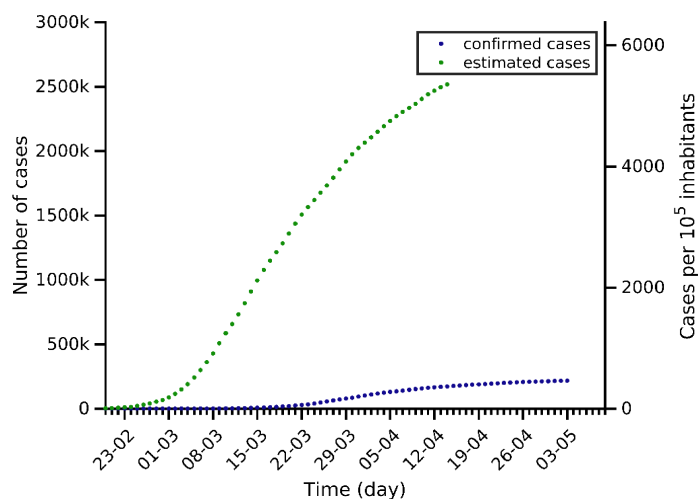
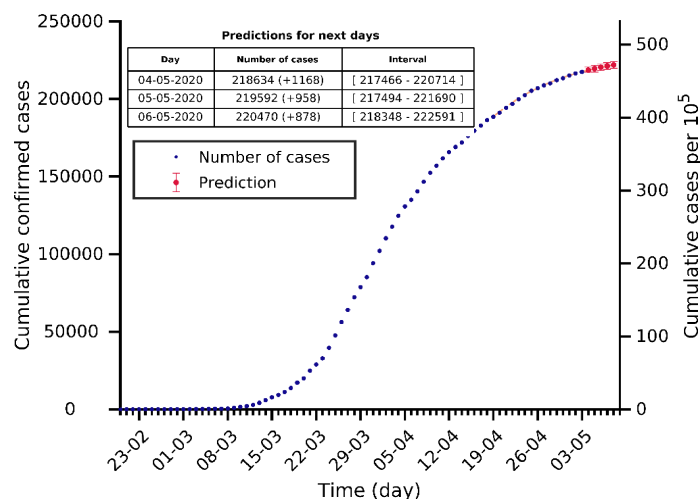


Deaths /
cumulated
reported cases

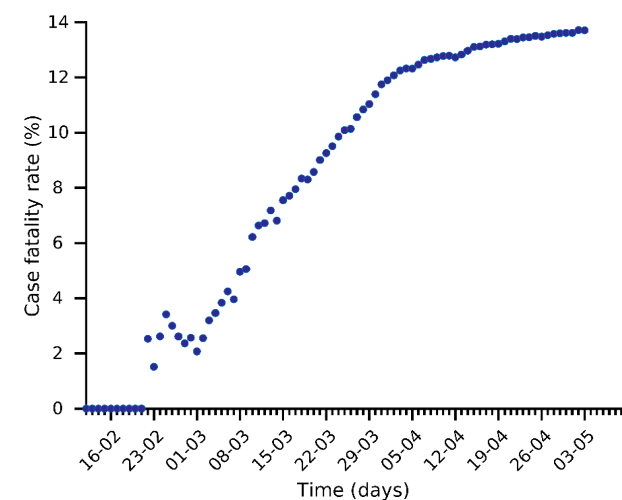
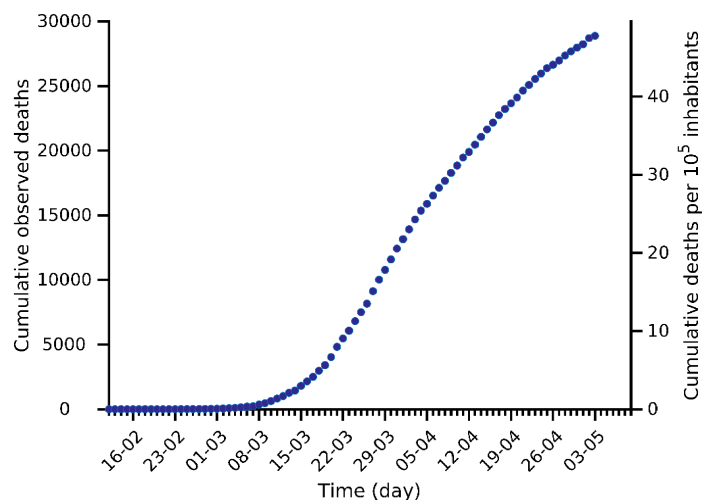
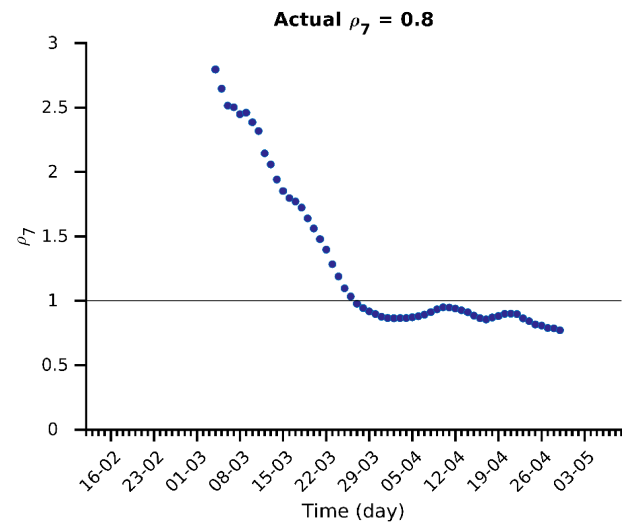
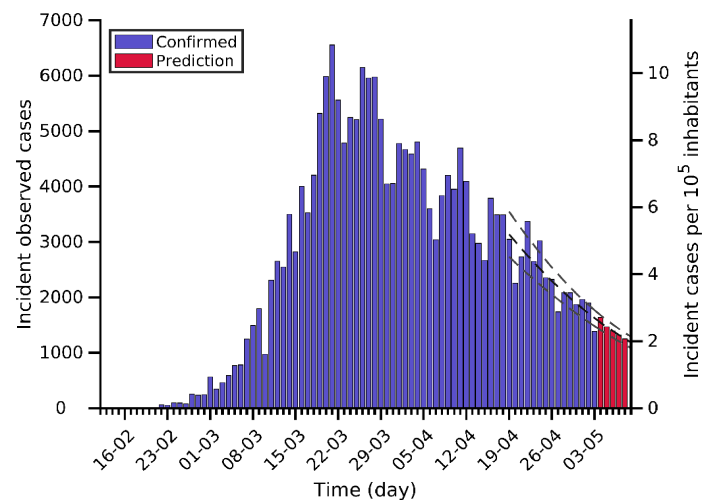
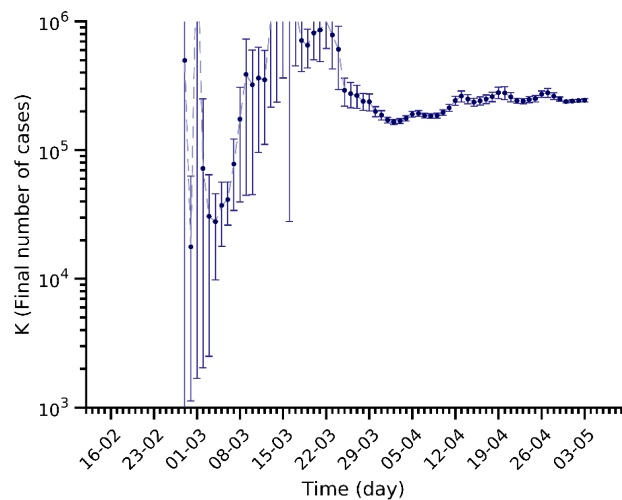
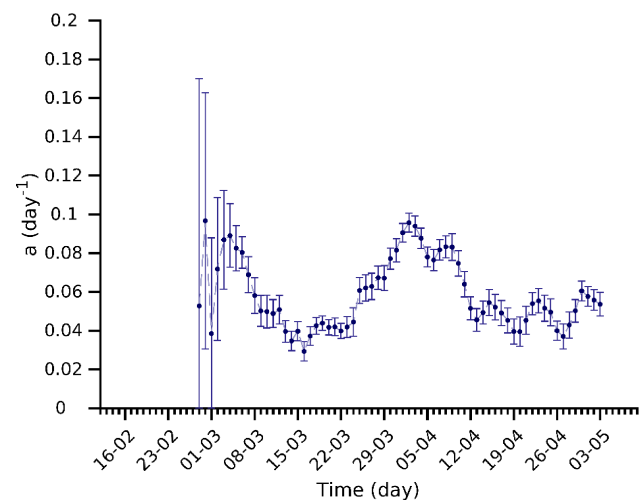
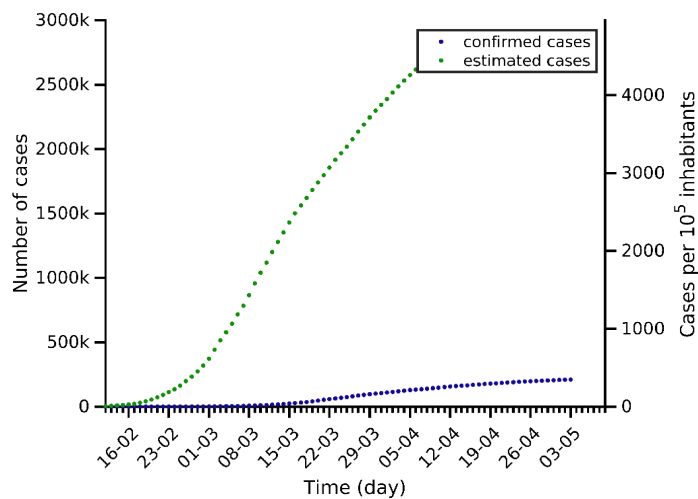
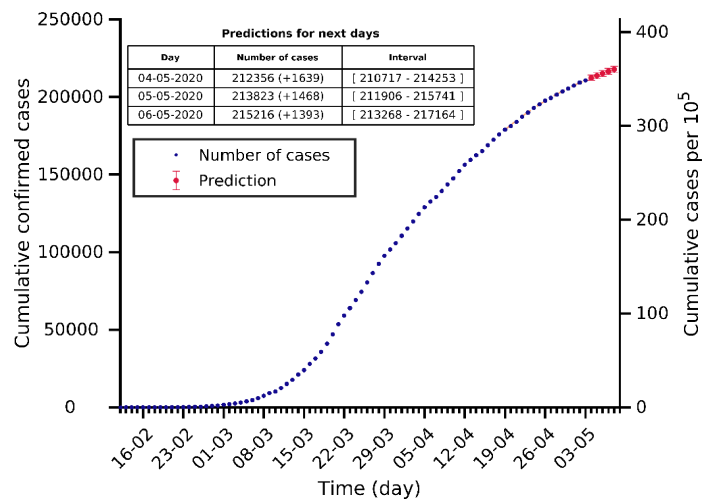
(1) Analysis and prediction of COVID-19 for EU+EFTA+UK

Data obtained from <https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases>

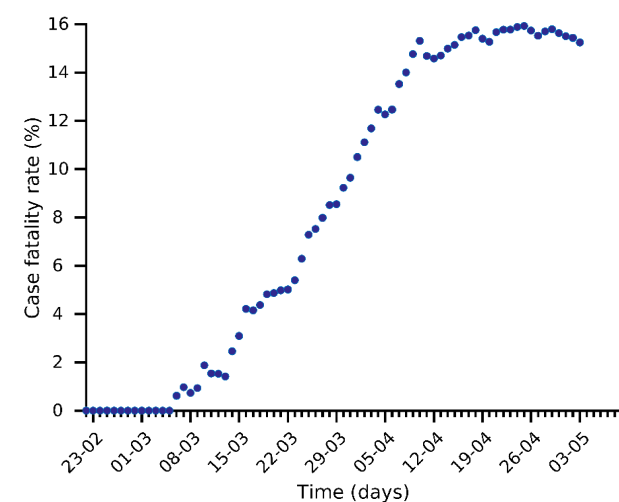
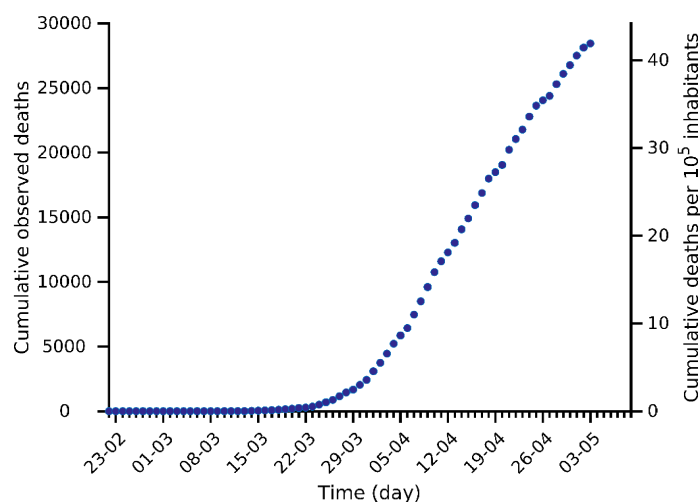
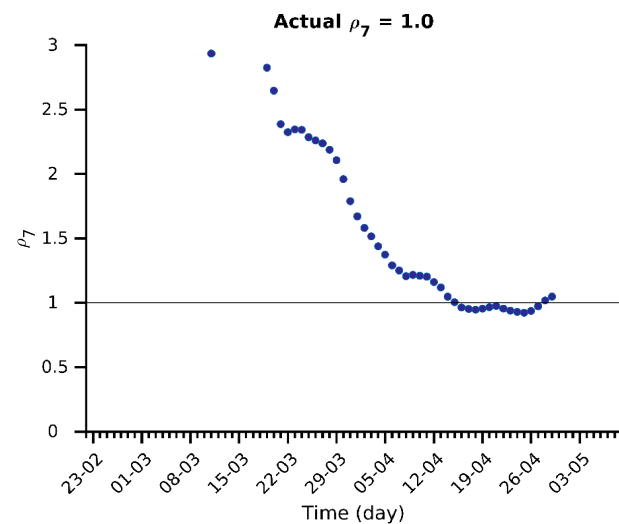
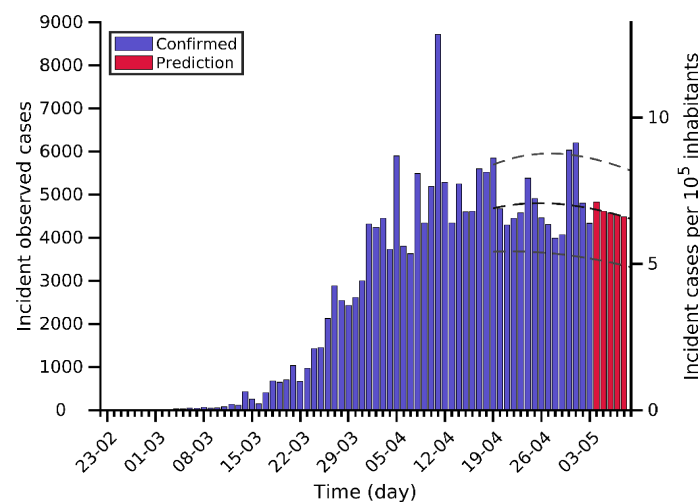
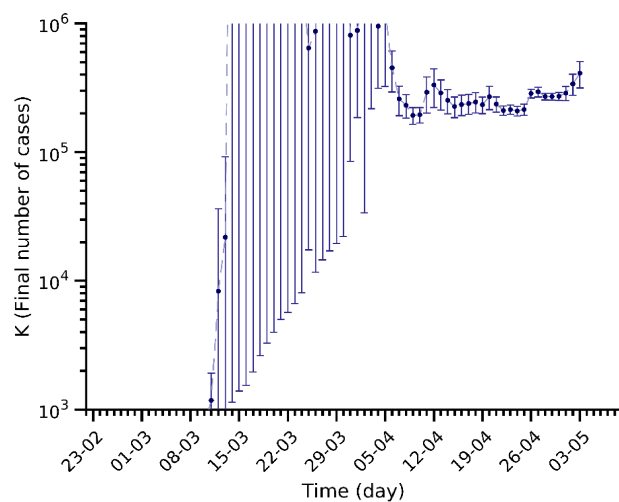
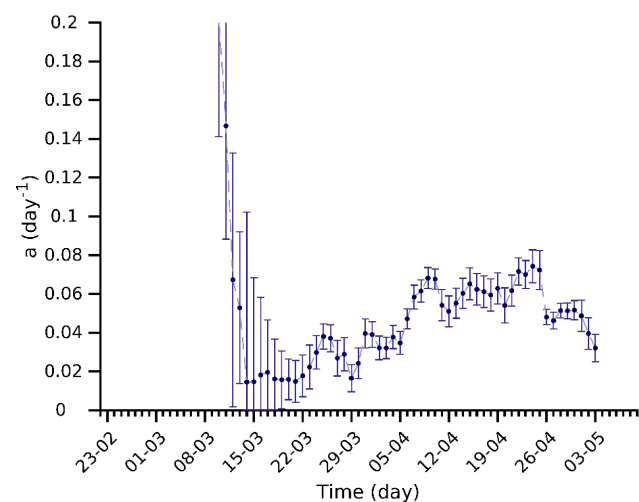
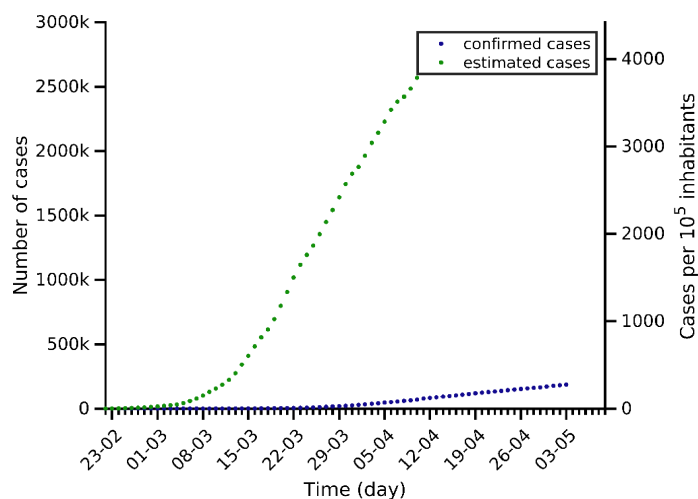
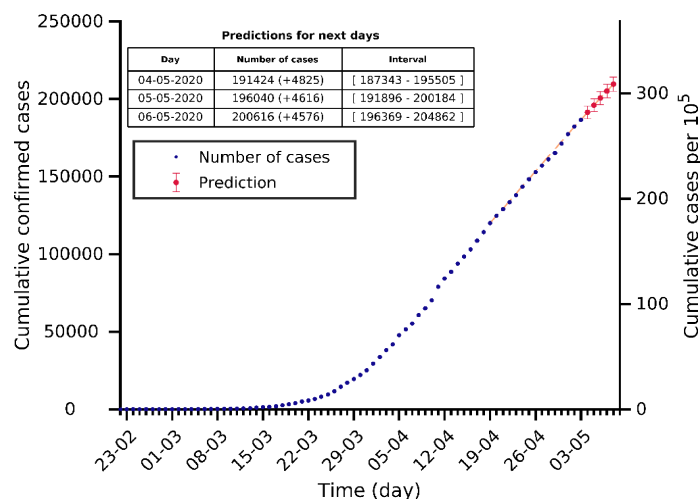
Spain 03-05-2020. Population: 47.0M. Current cumulated incidence: 462/10⁵



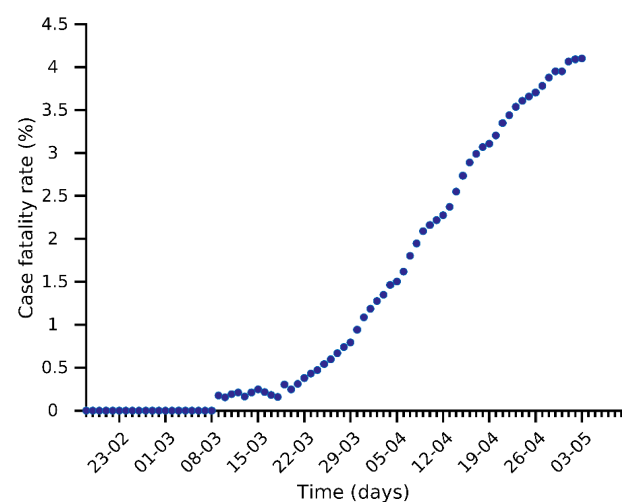
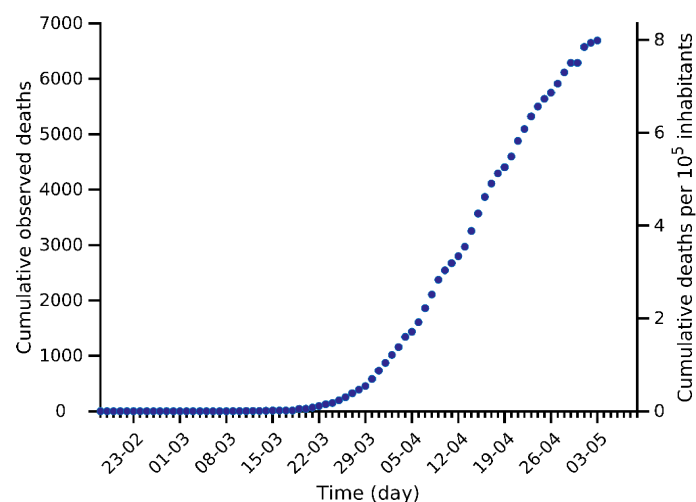
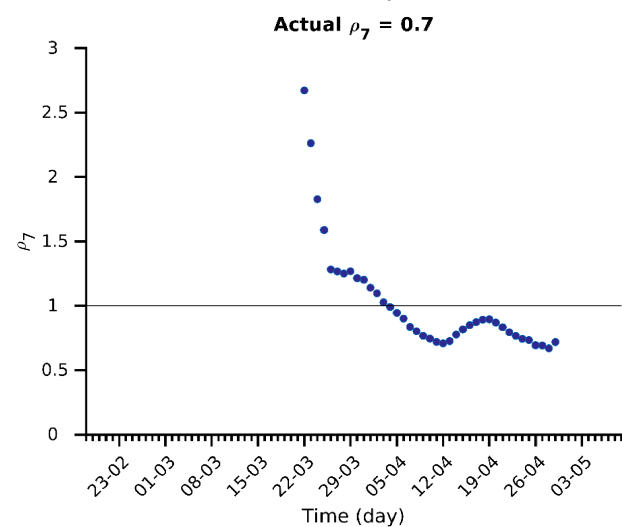
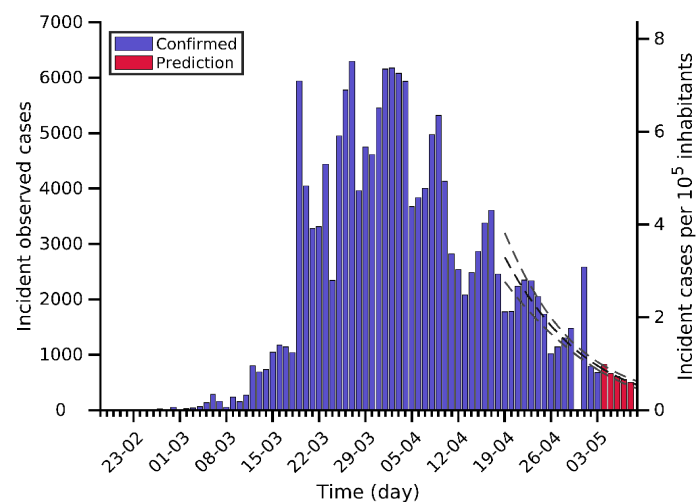
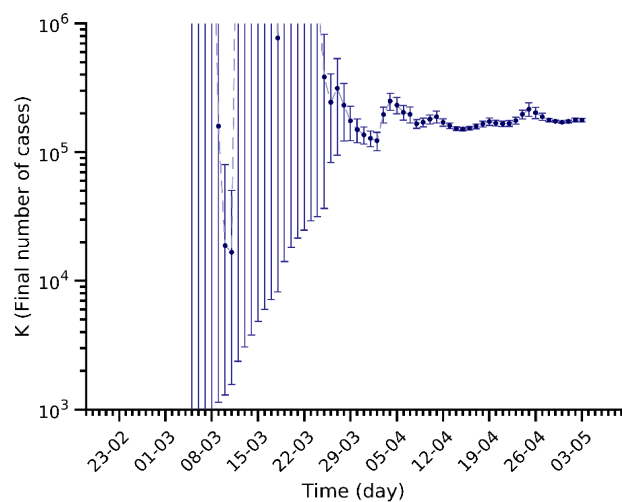
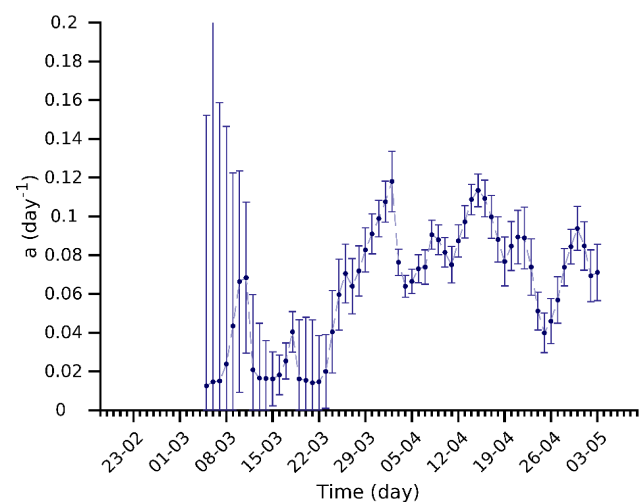
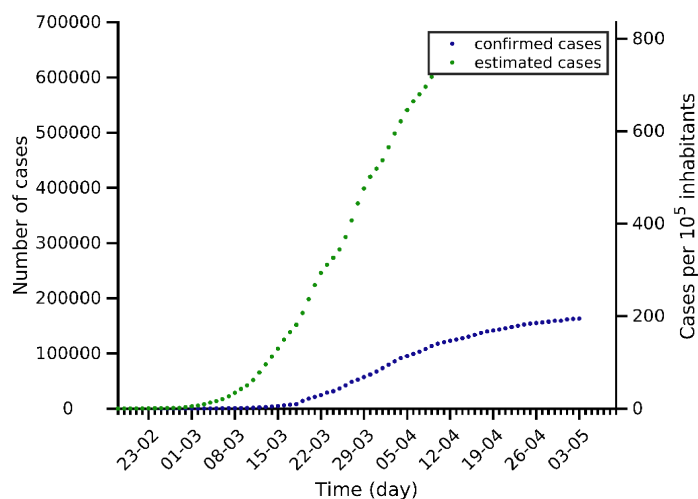
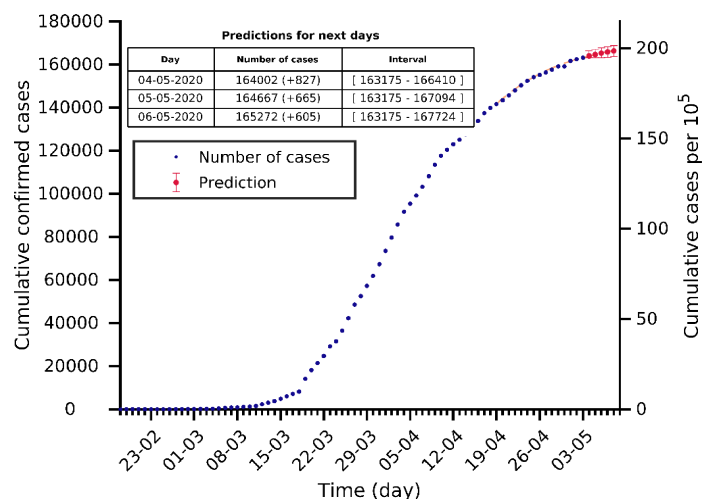
Italy 03-05-2020. Population: 60.5M. Current cumulated incidence: 349/10⁵



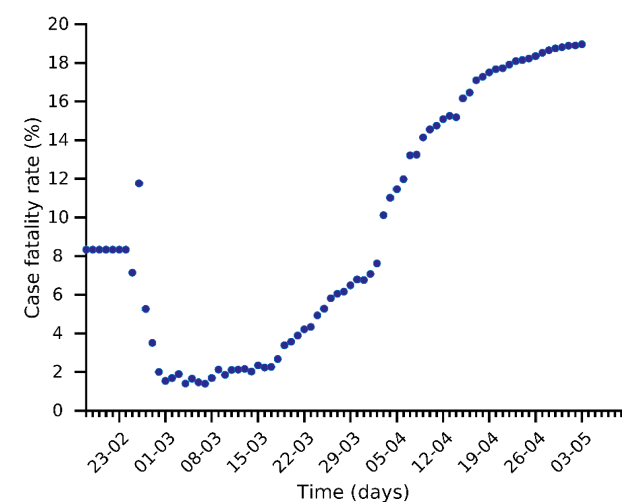
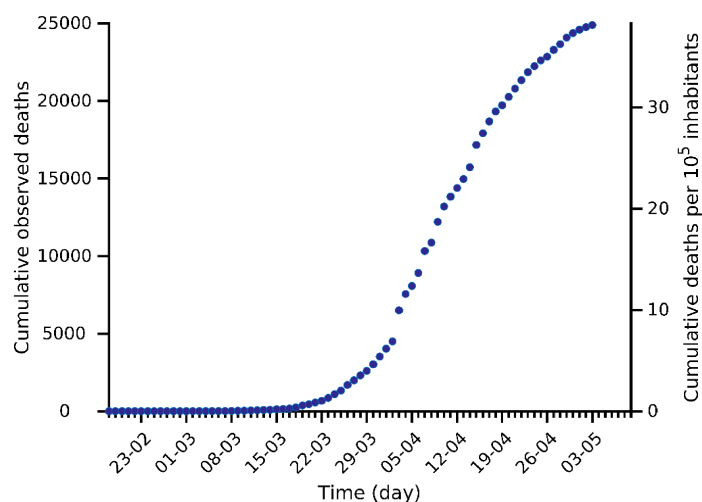
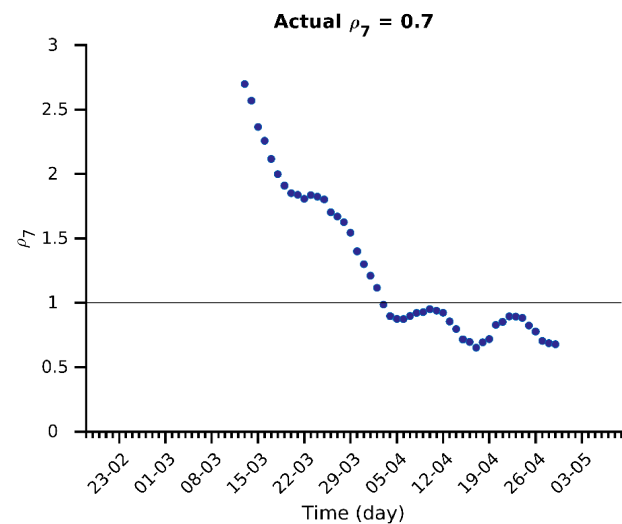
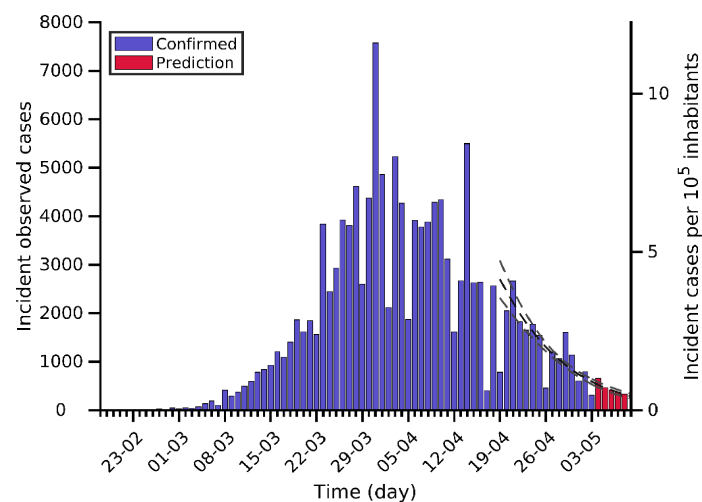
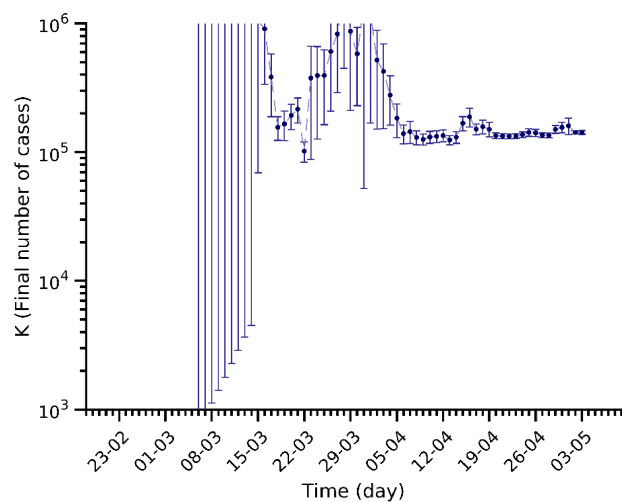
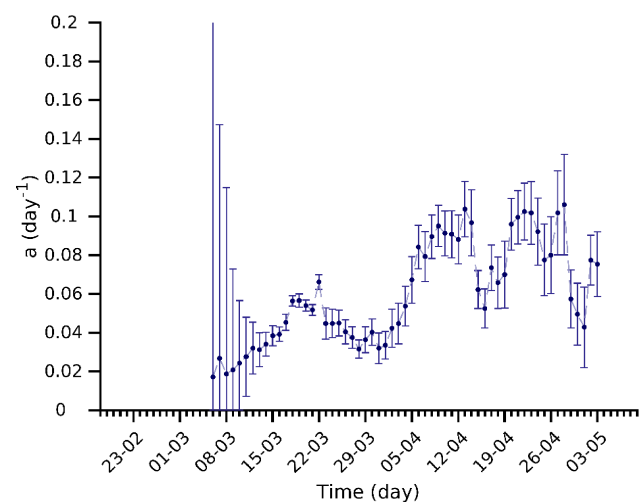
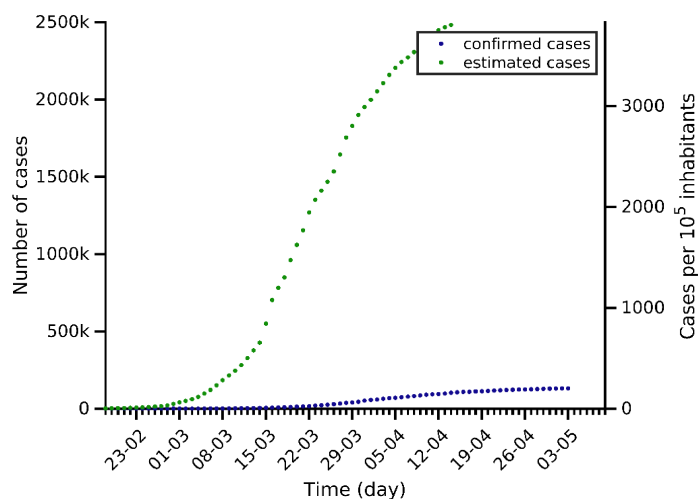
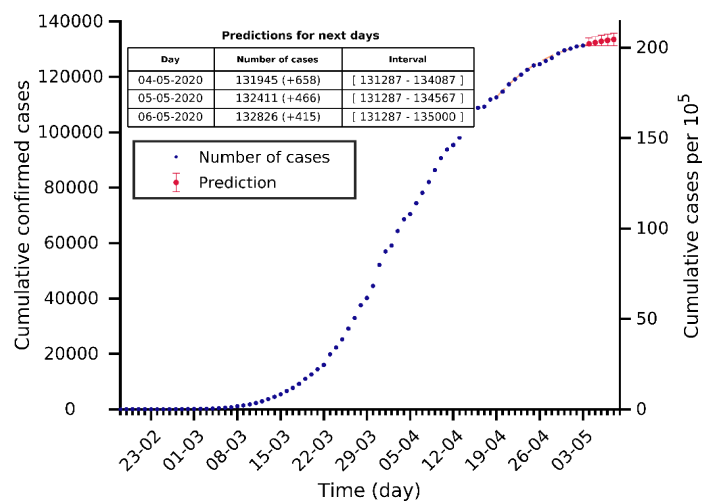
UK 03-05-2020. Population: 67.9M. Current cumulated incidence: 275/10⁵

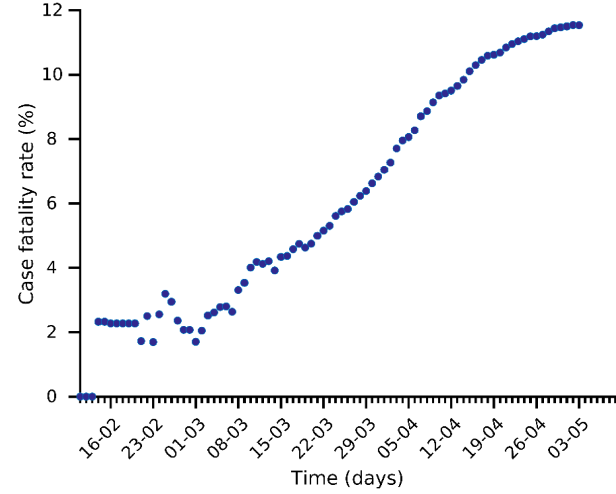
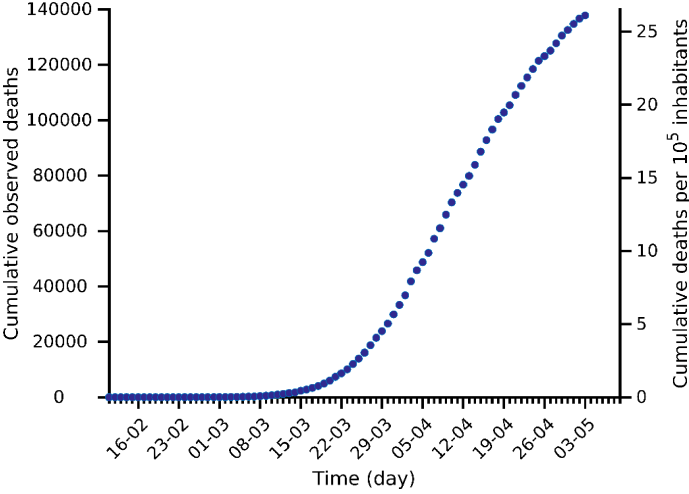
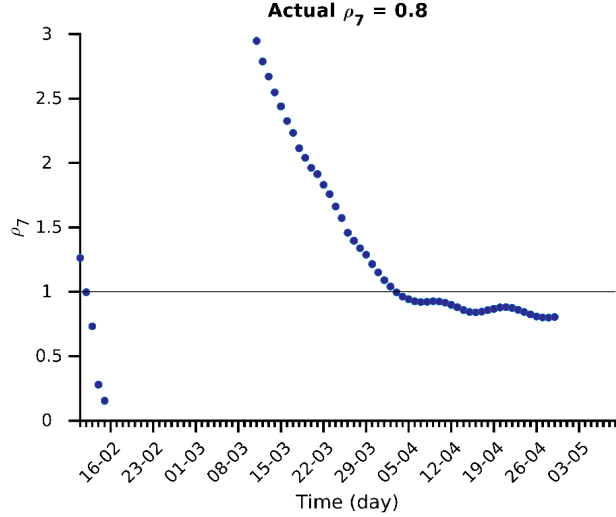
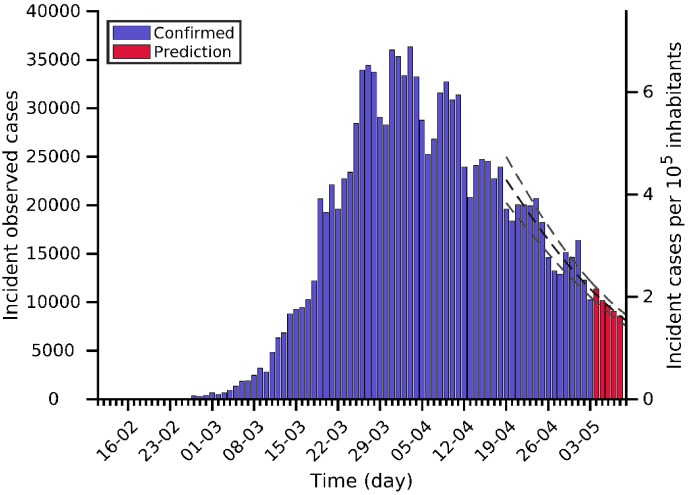
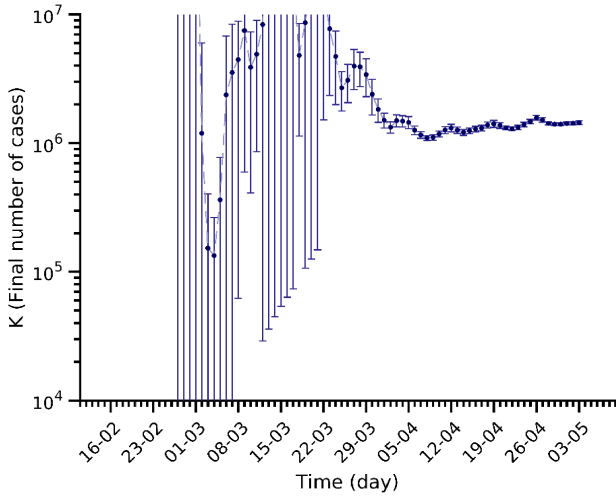
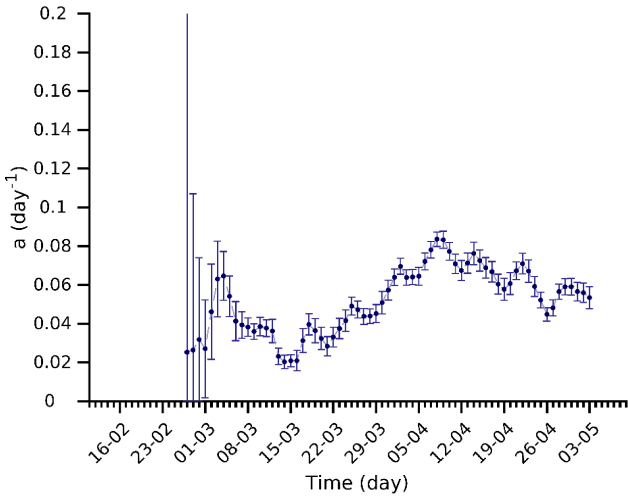
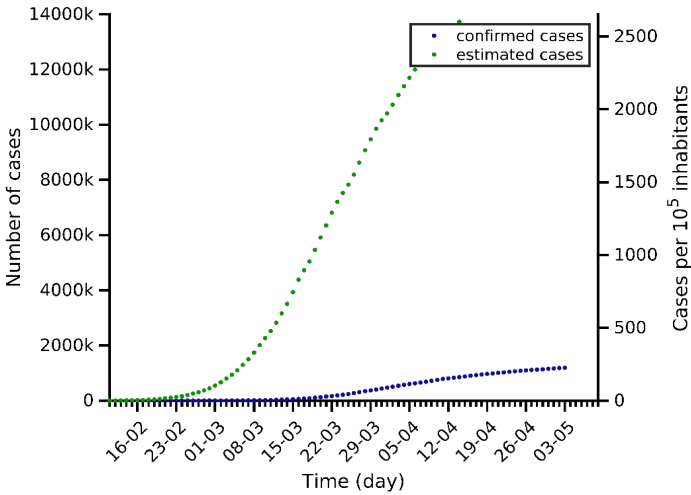
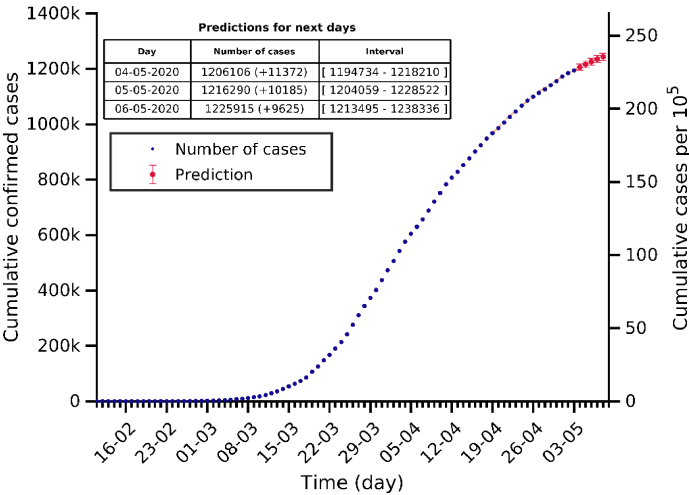


Germany 03-05-2020. Population: 83.8M. Current cumulated incidence: 195/10⁵

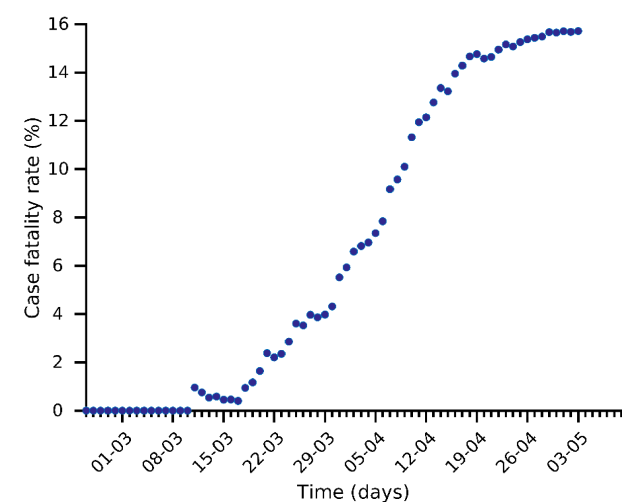
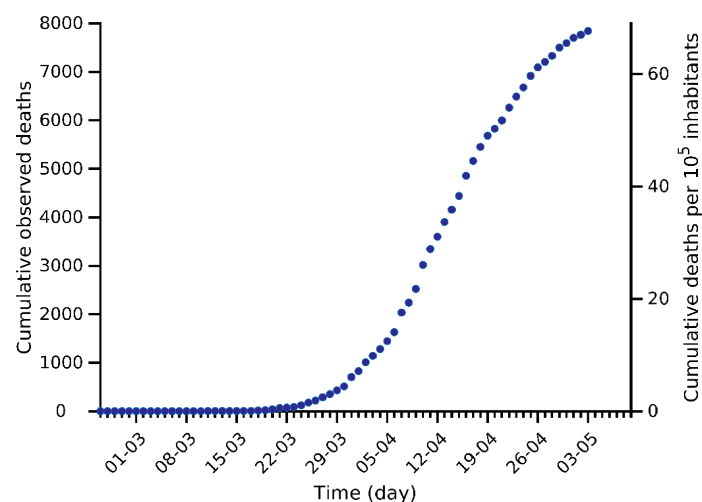
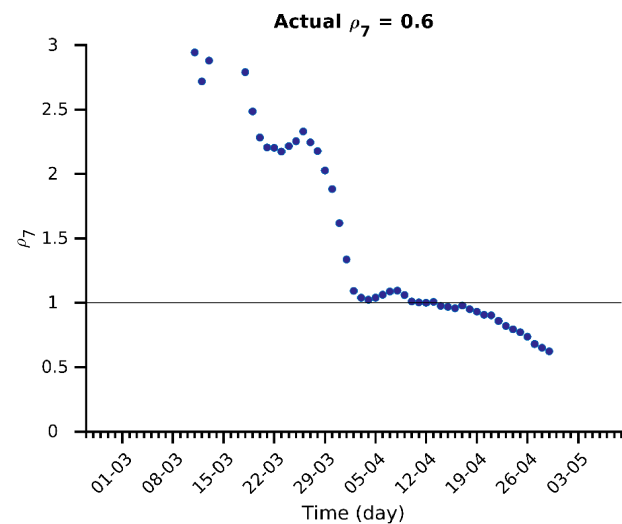
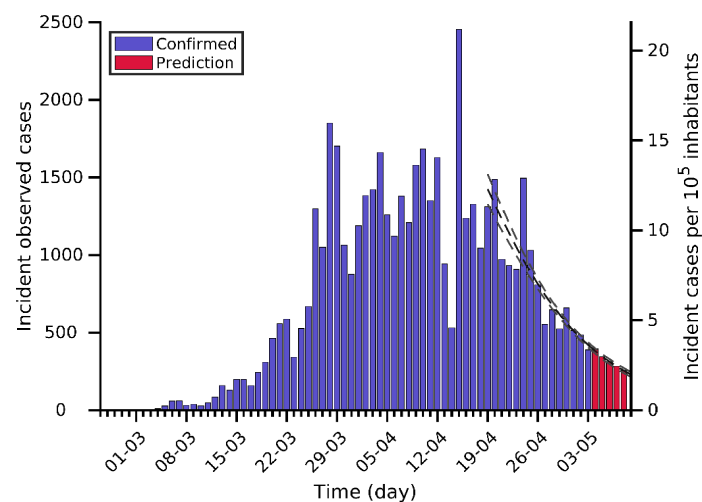
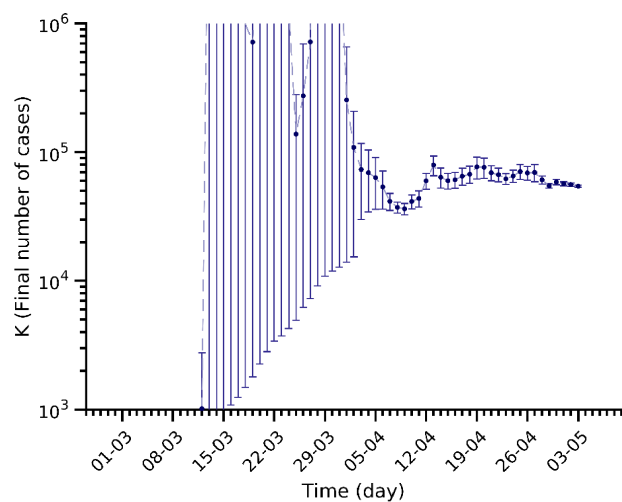
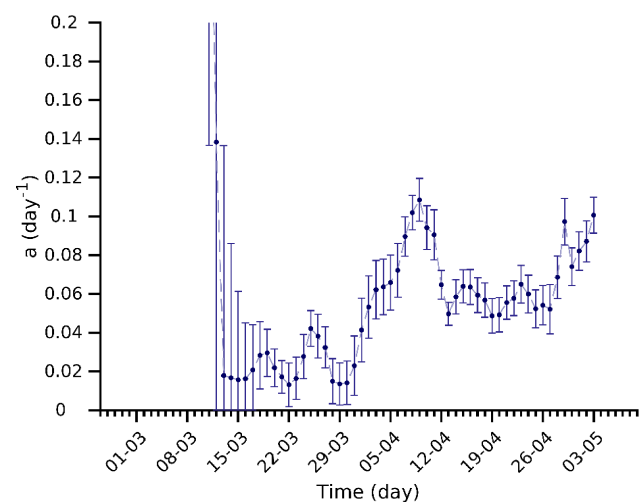
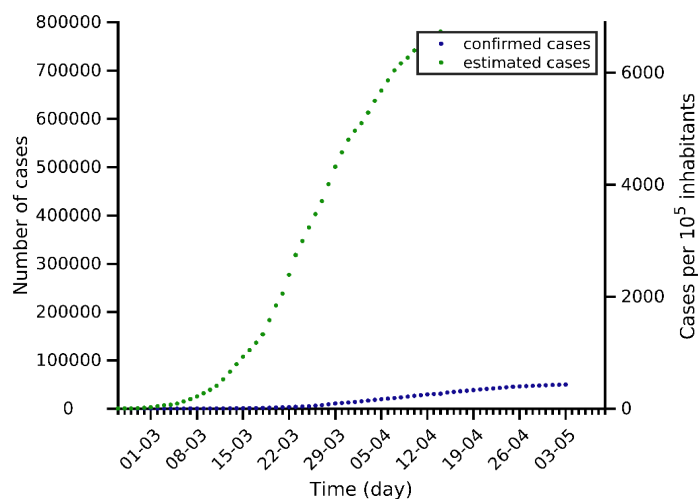
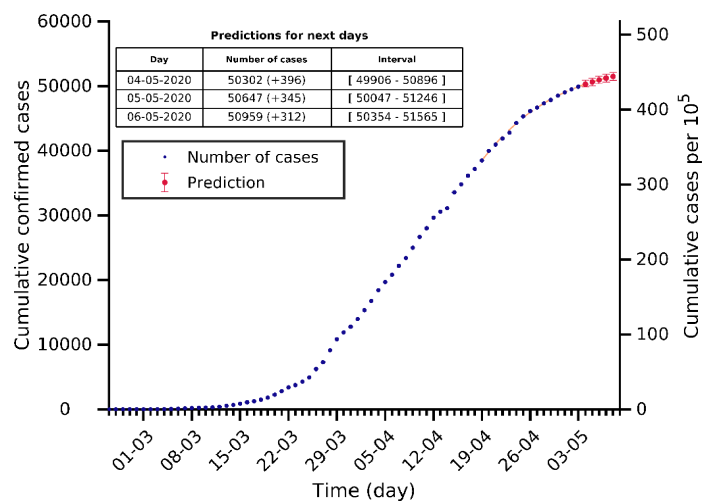


France 03-05-2020. Population: 65.3M. Current cumulated incidence: 201/10⁵

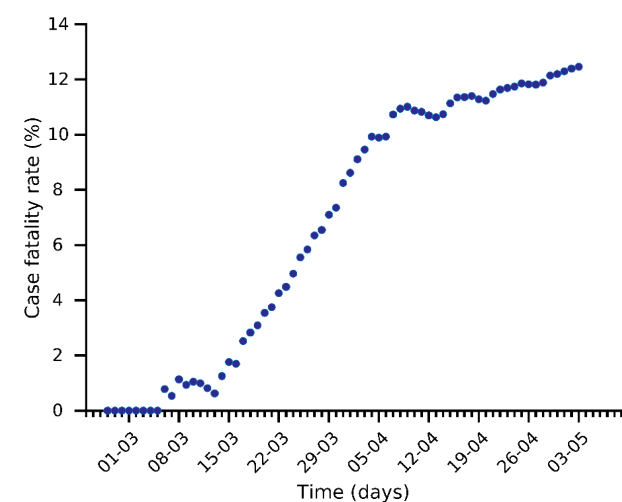
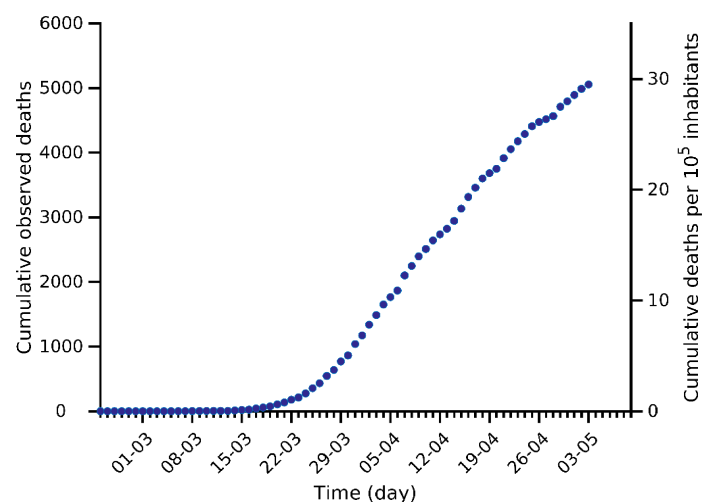
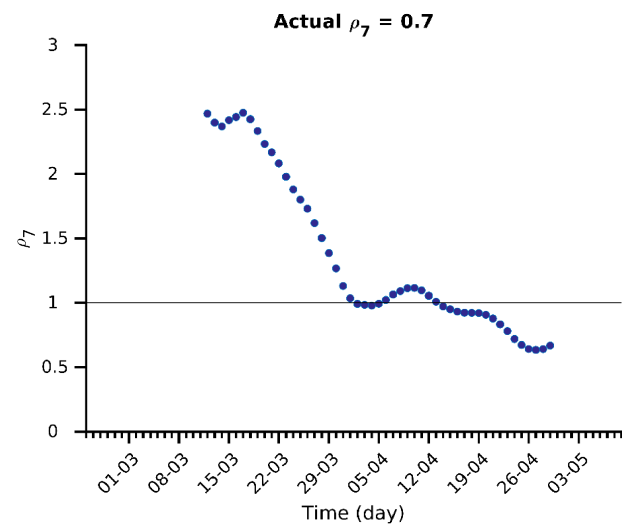
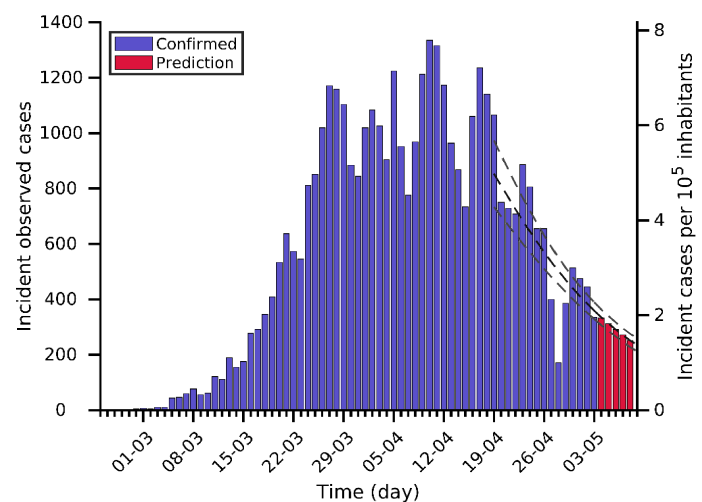
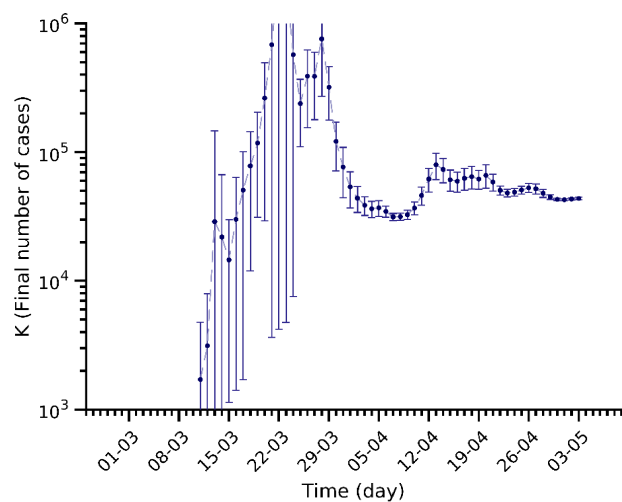
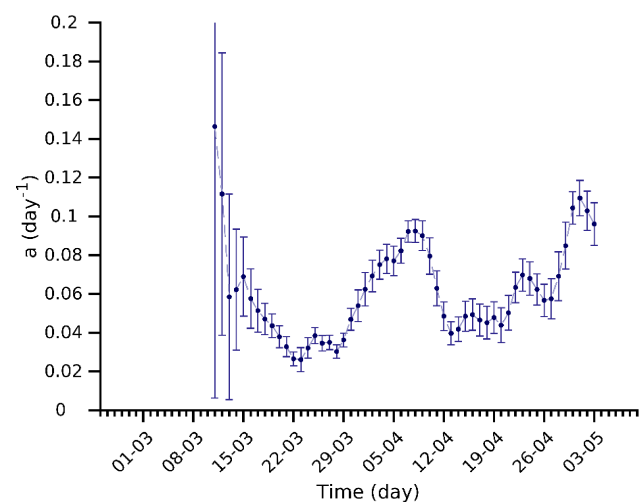
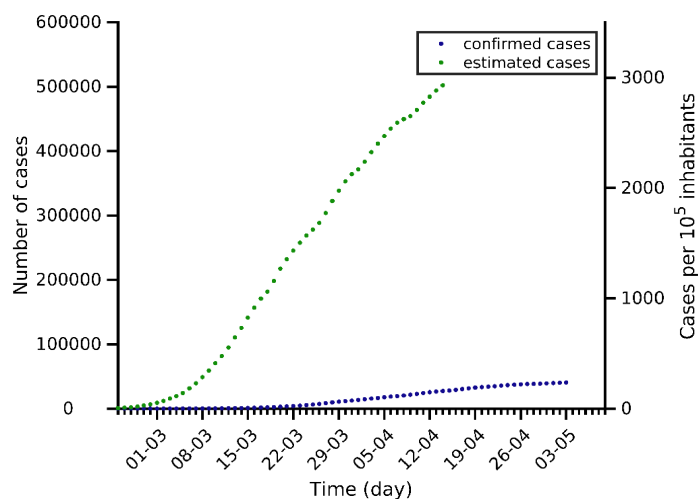
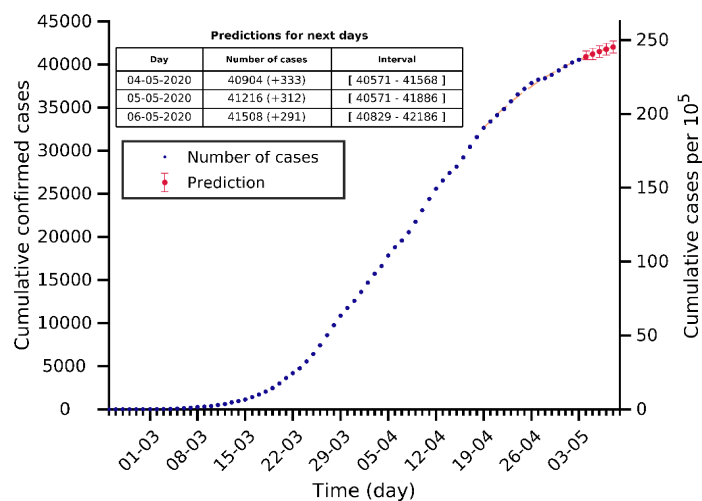




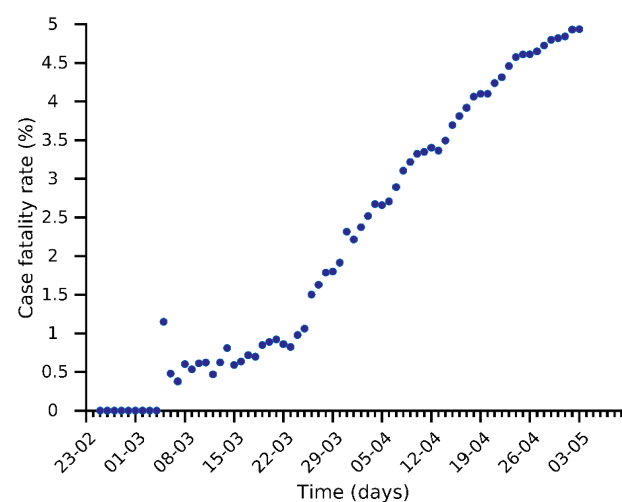
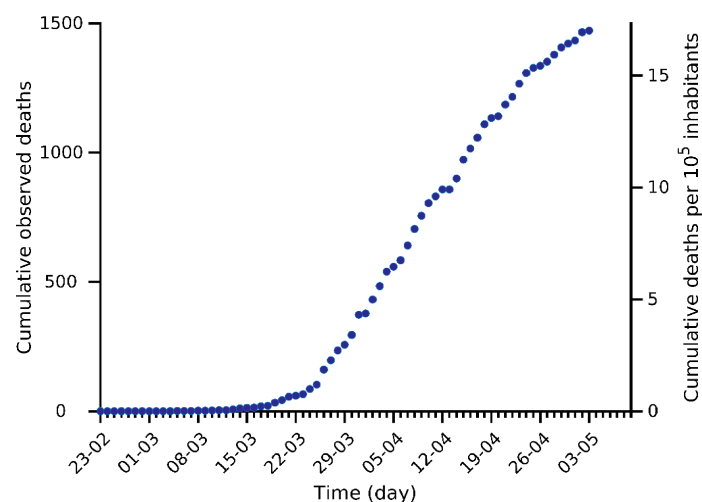
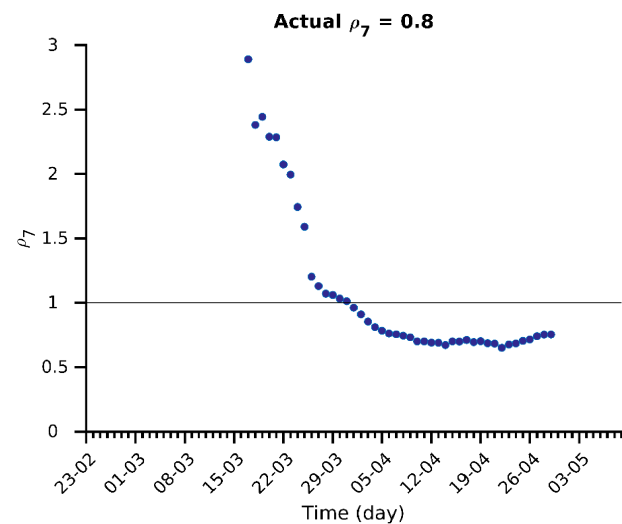
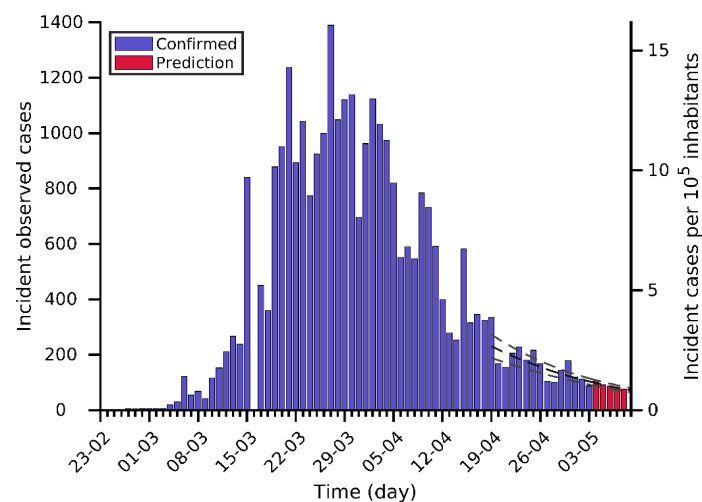
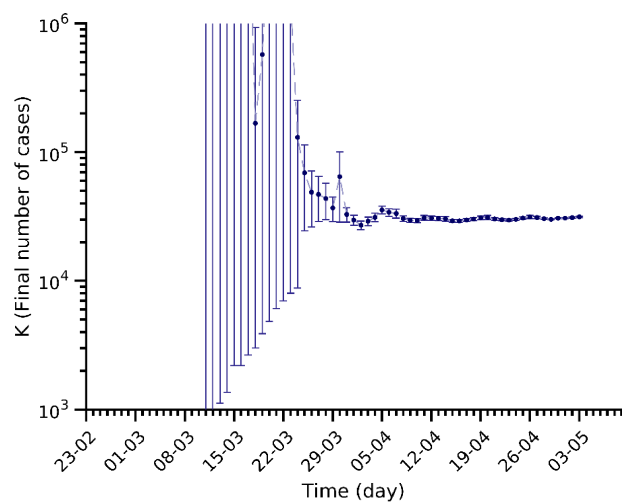
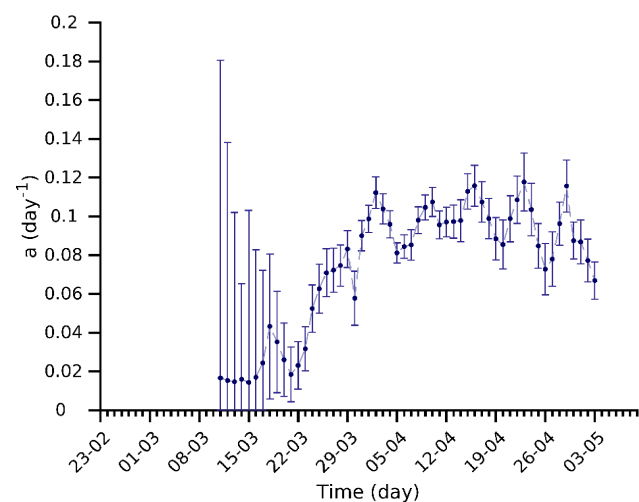
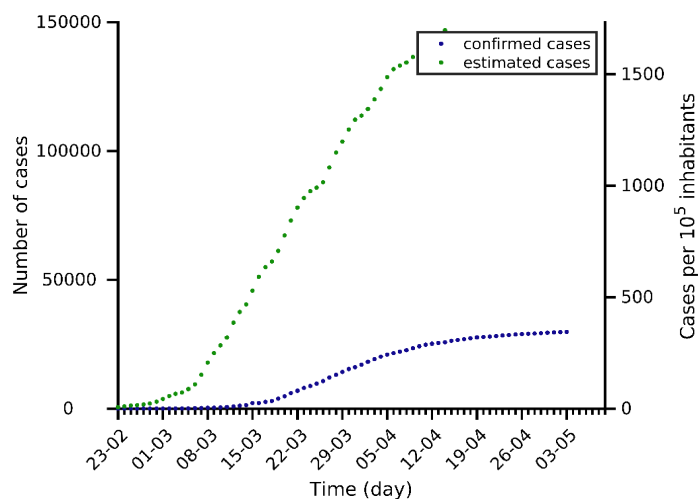
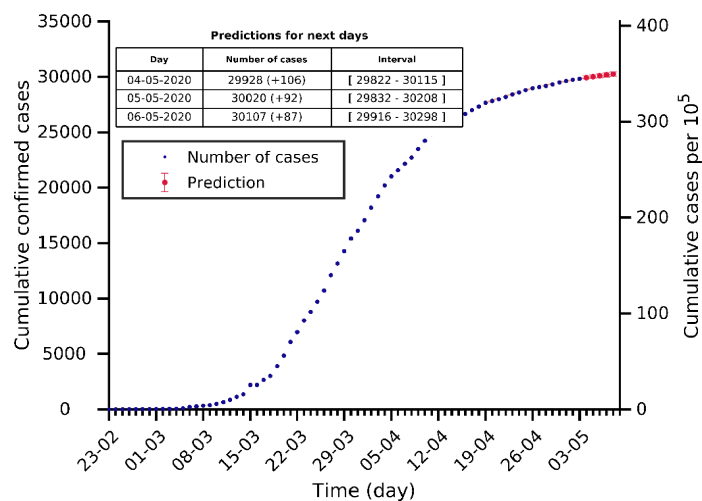
Belgium 03-05-2020. Population: 11.6M. Current cumulated incidence: 431/10⁵



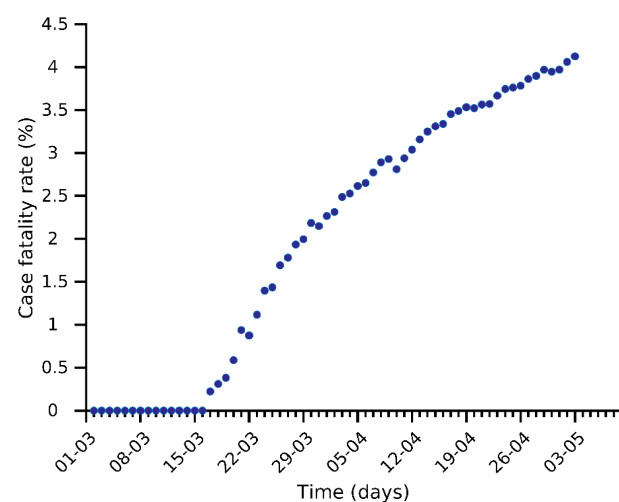
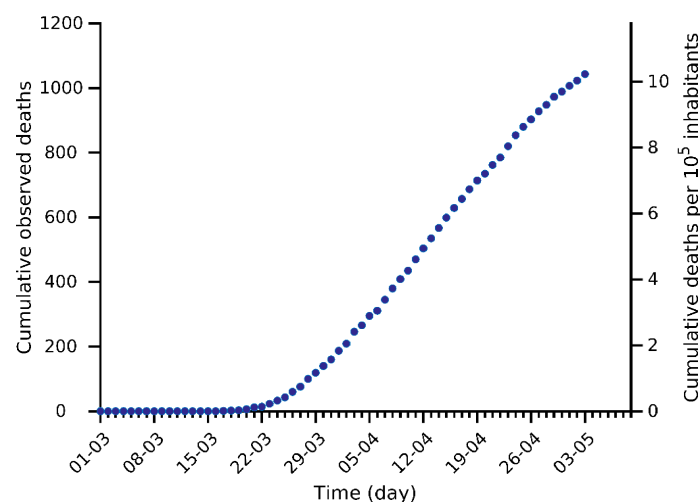
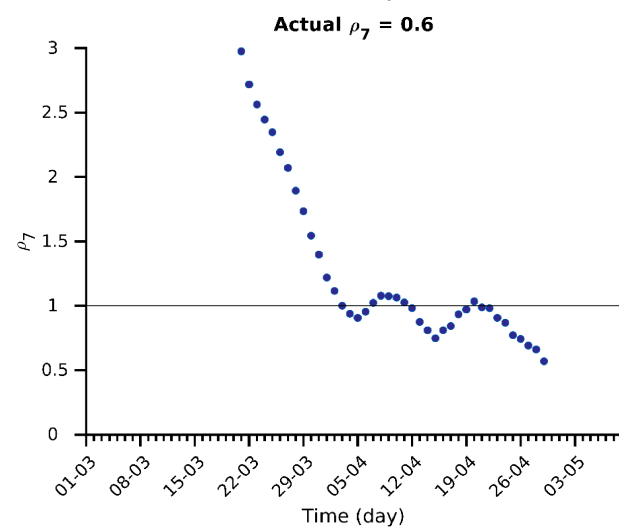
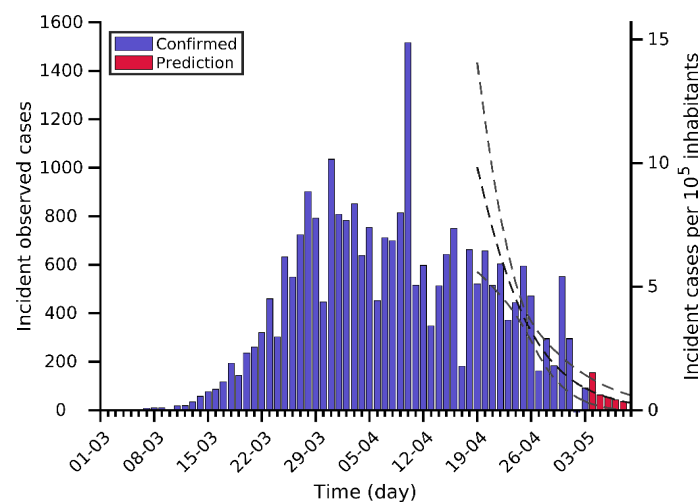
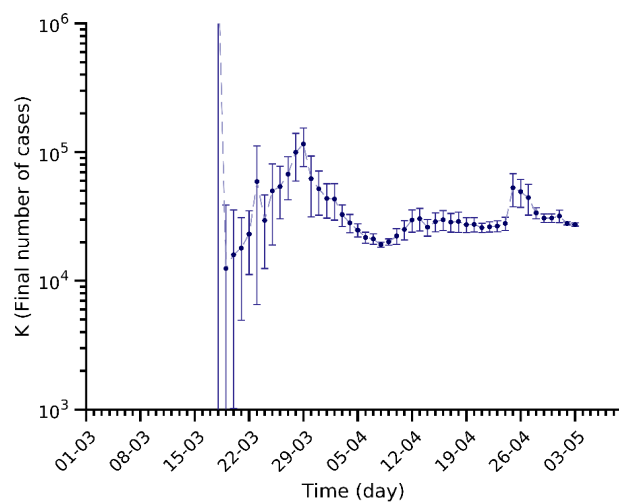
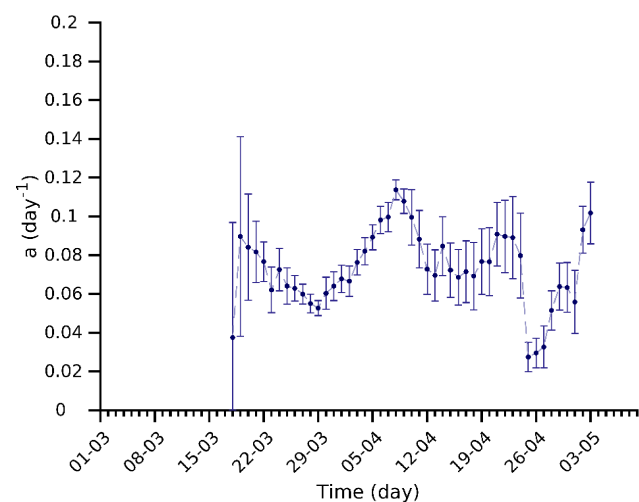
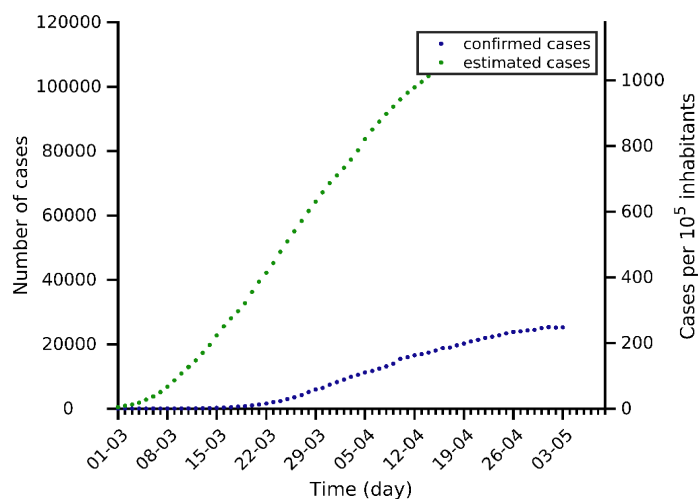
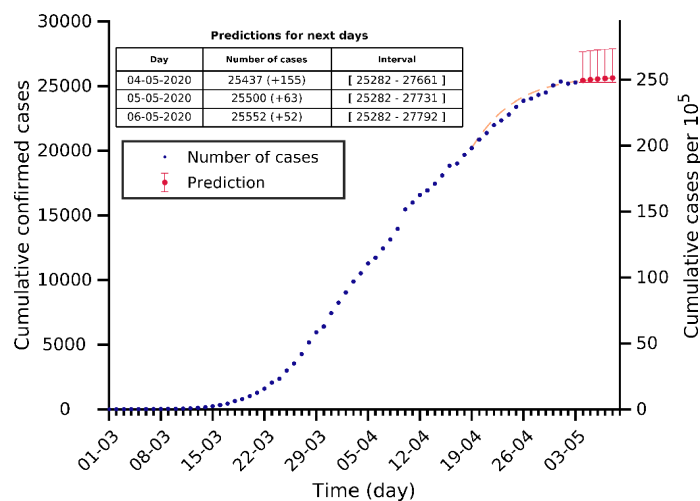
Netherlands 03-05-2020. Population: 17.1M. Current cumulated incidence: 237/10⁵



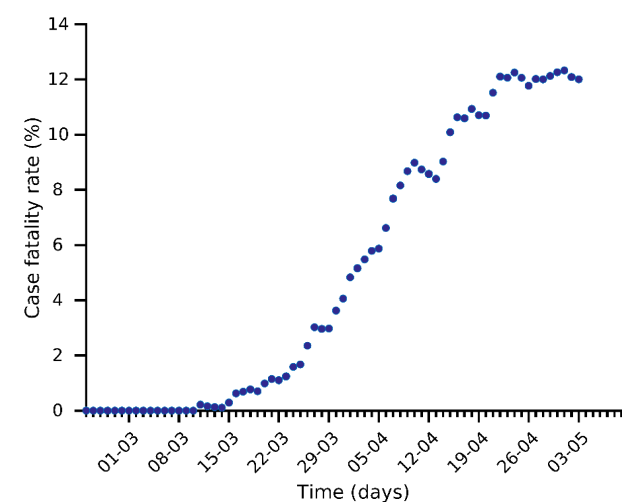
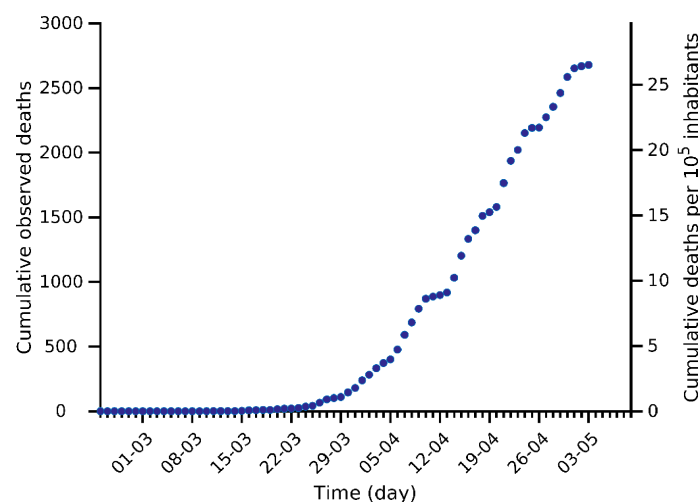
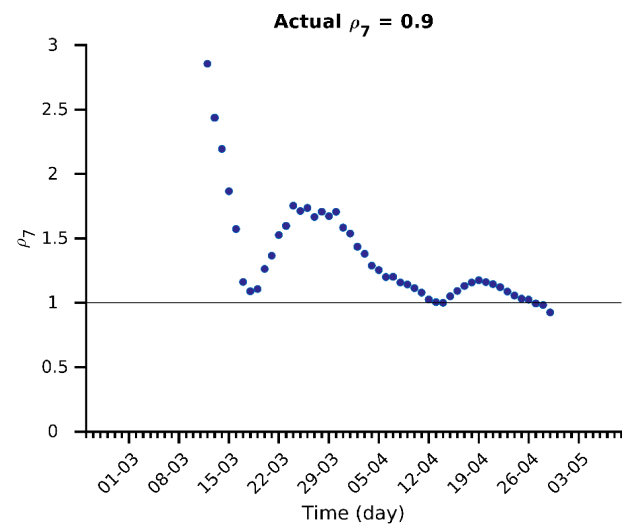
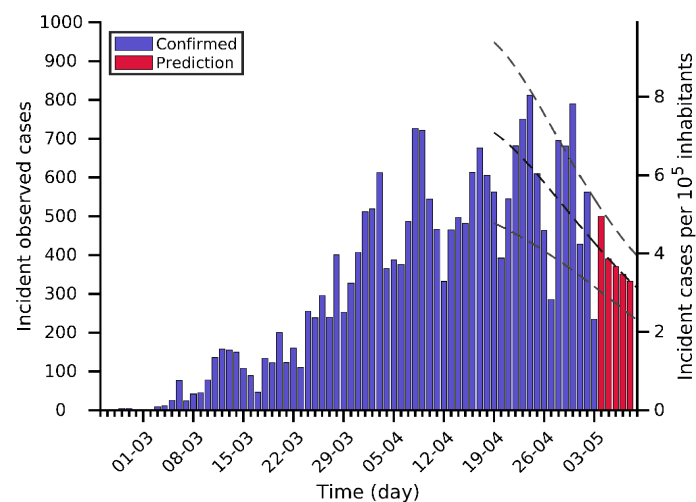
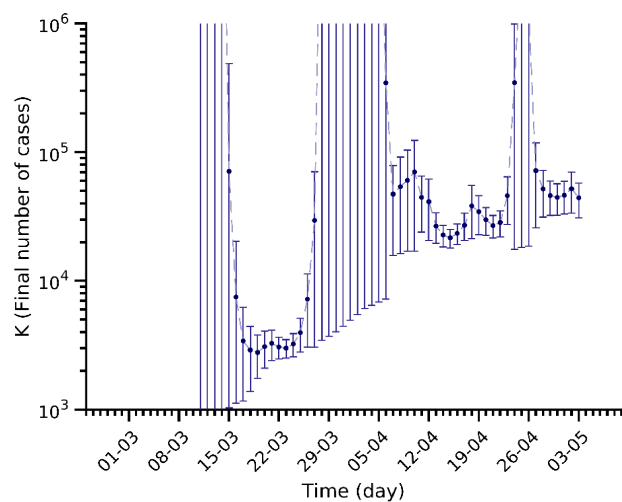
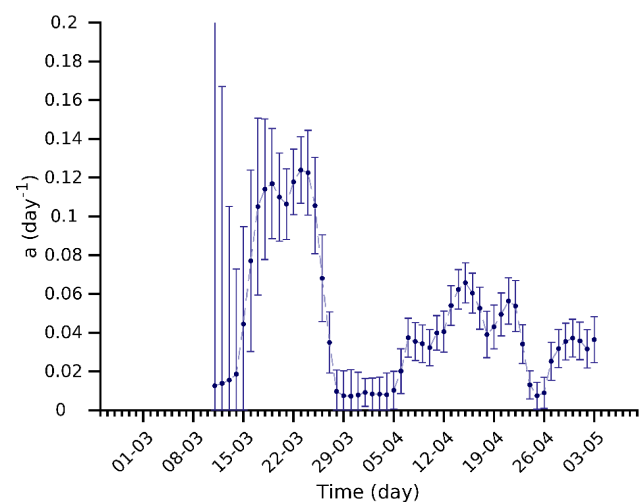
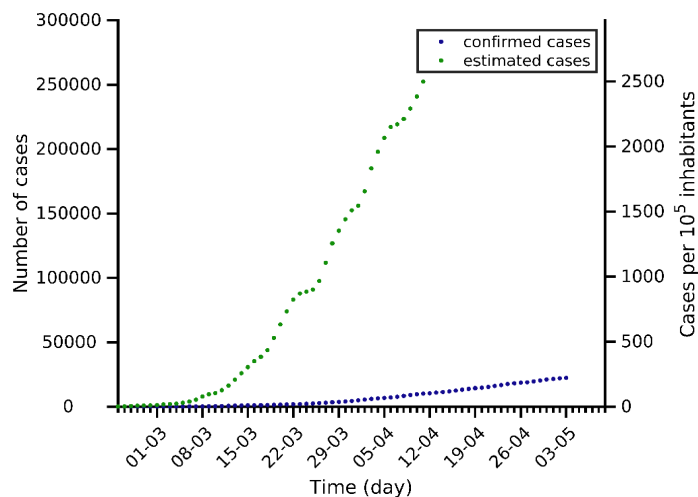
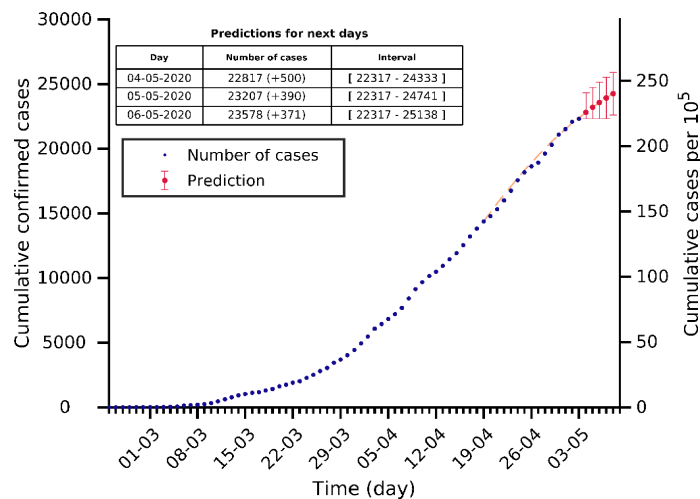
Switzerland 03-05-2020. Population: 8.7M. Current cumulated incidence: 345/10⁵



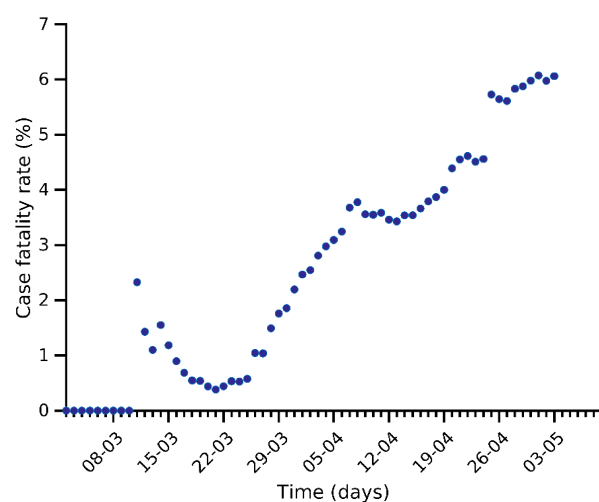
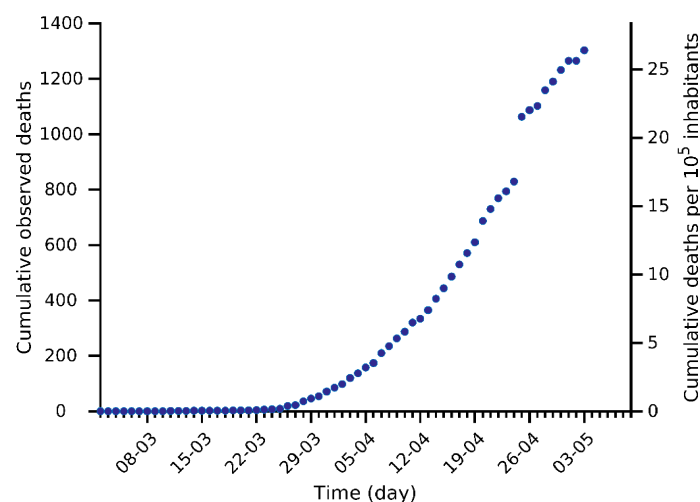
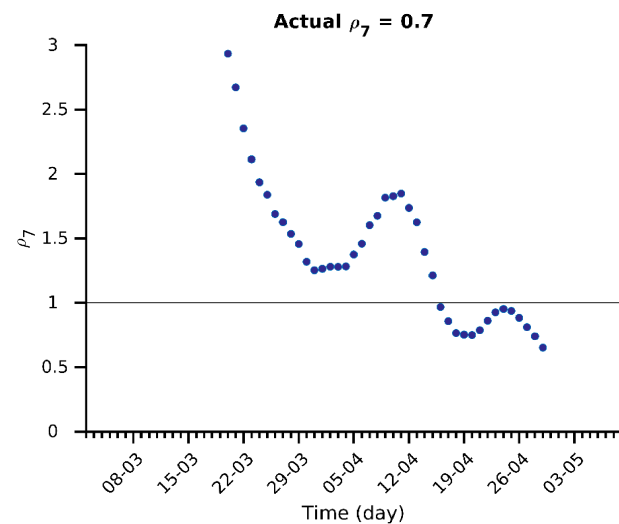
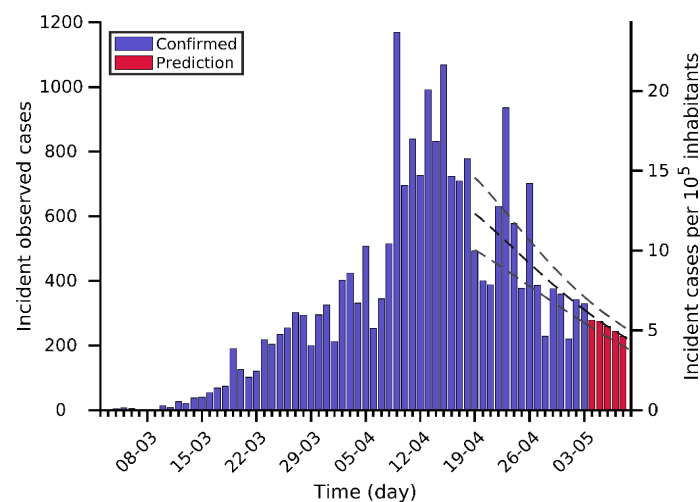
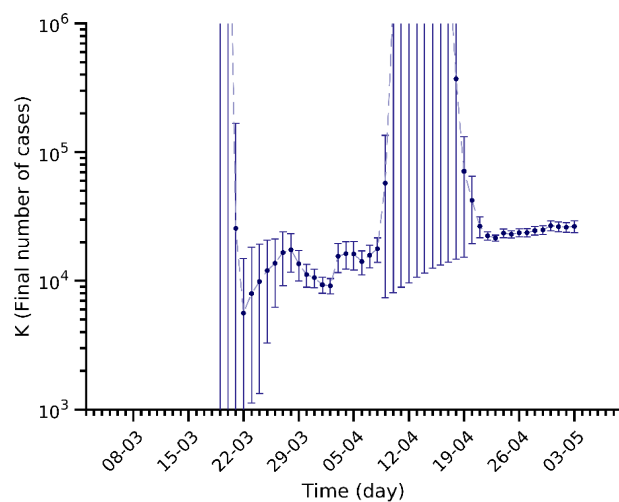
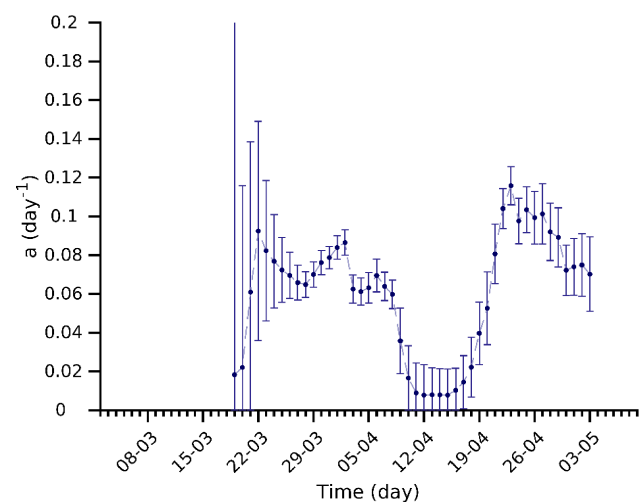
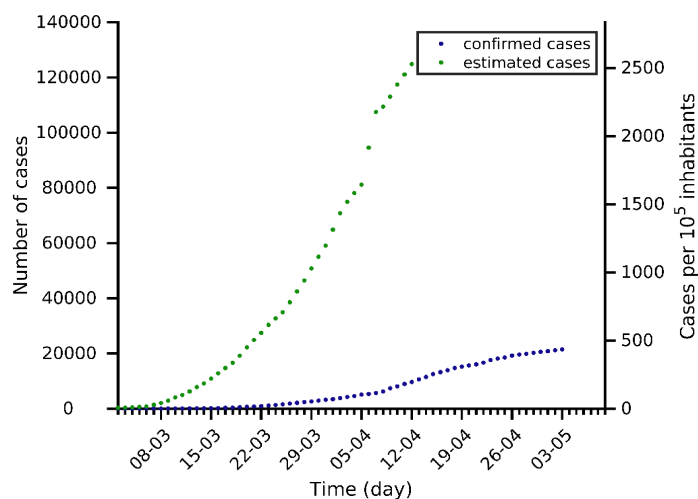
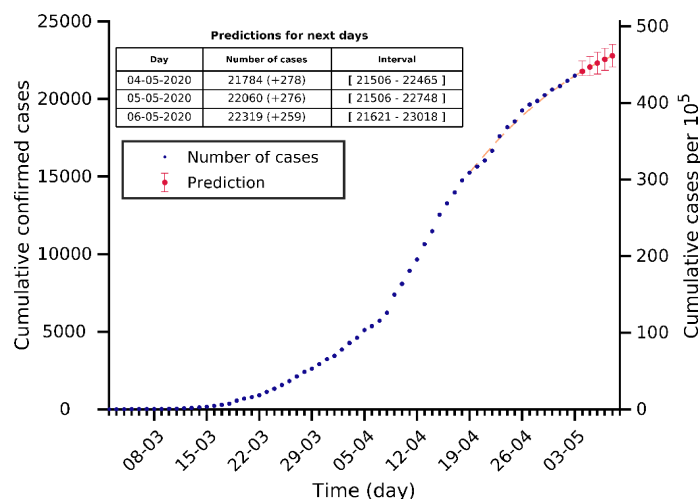
Portugal 03-05-2020. Population: 10.2M. Current cumulated incidence: 248/10⁵



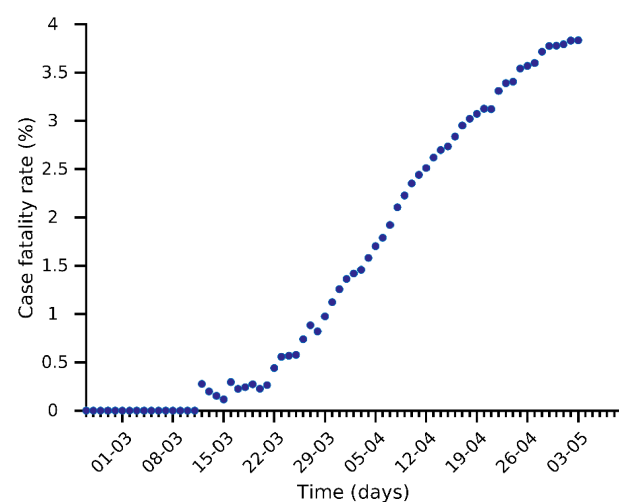
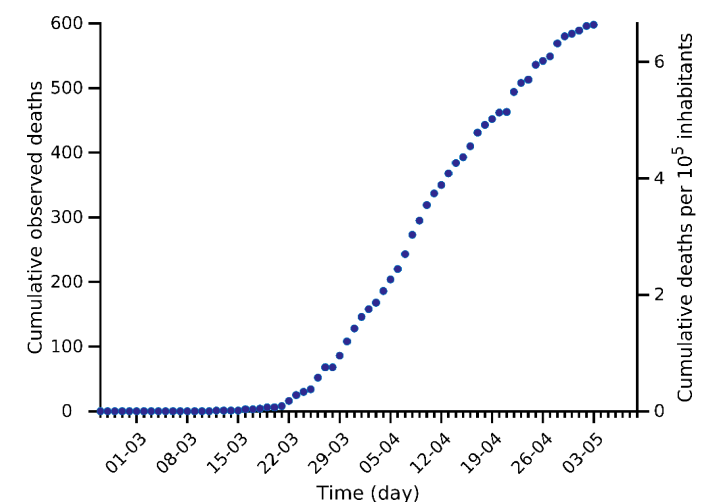
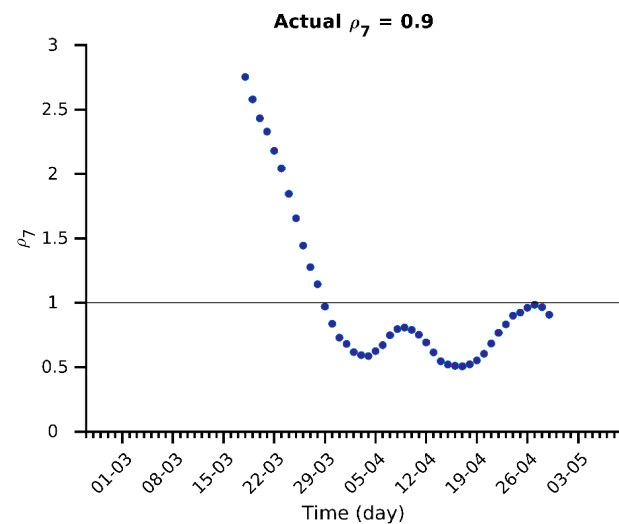
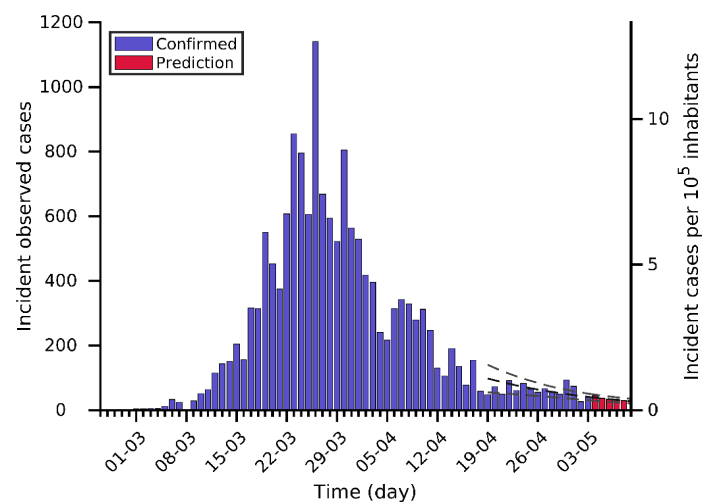
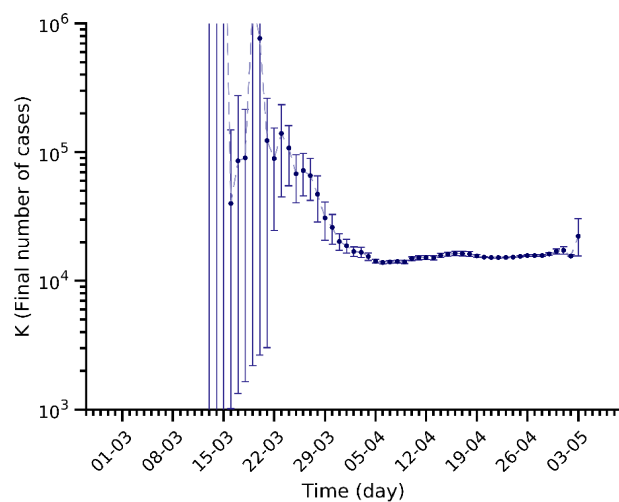
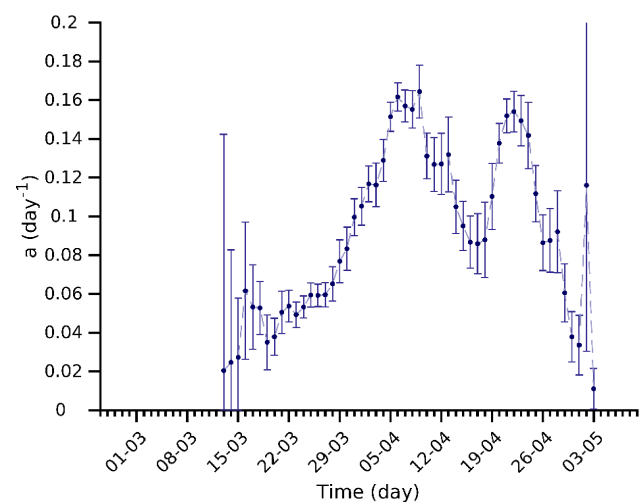
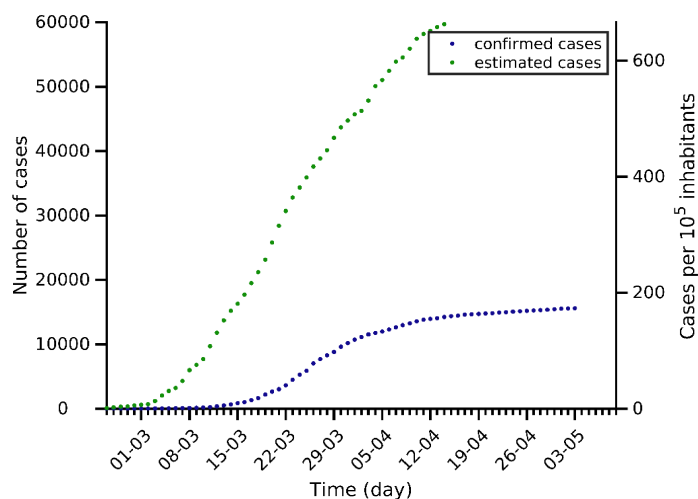
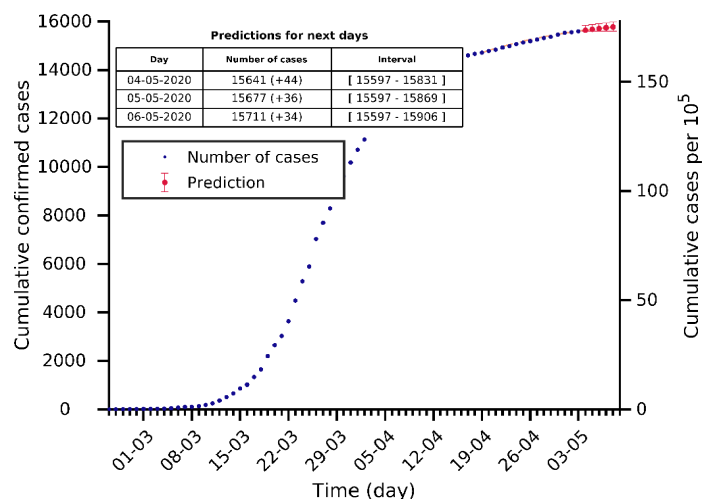
Sweden 03-05-2020. Population: 10.1M. Current cumulated incidence: 221/10⁵



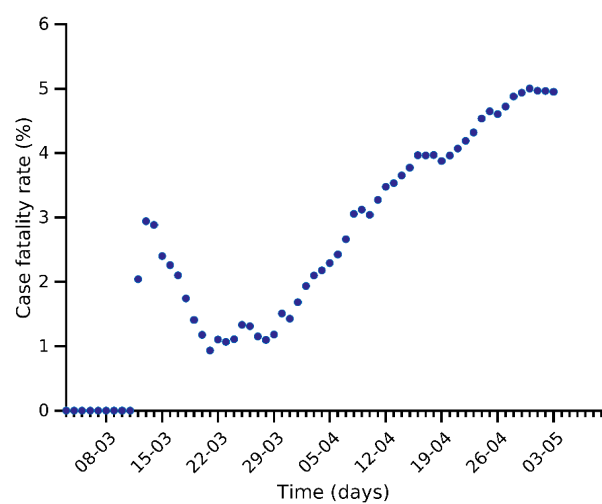
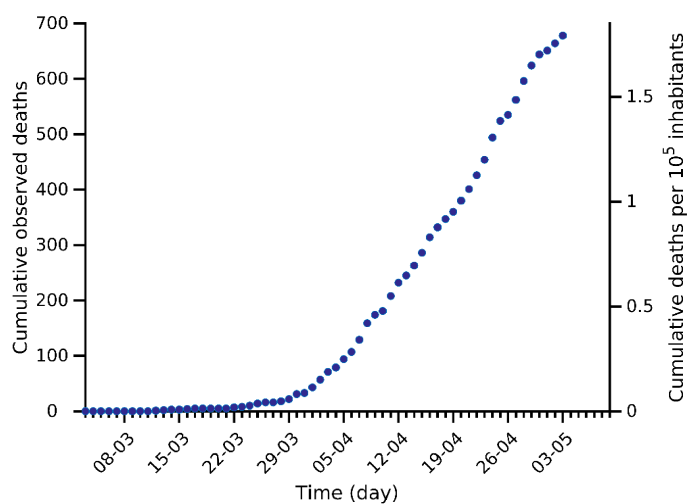
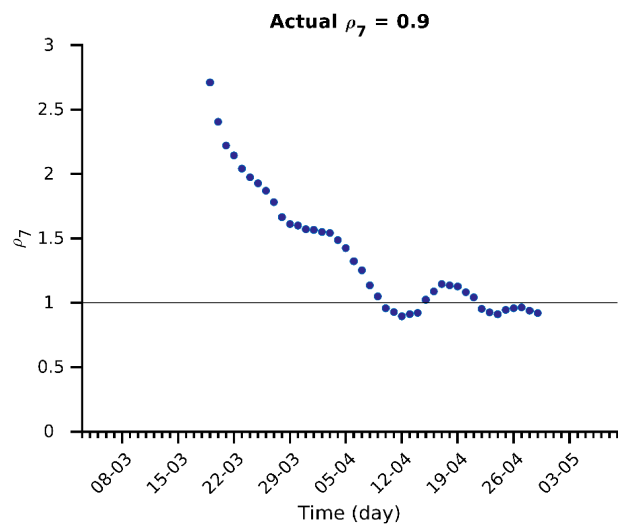
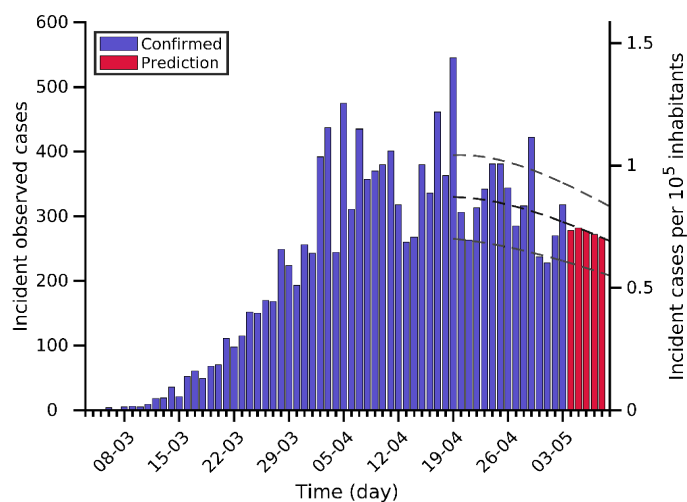
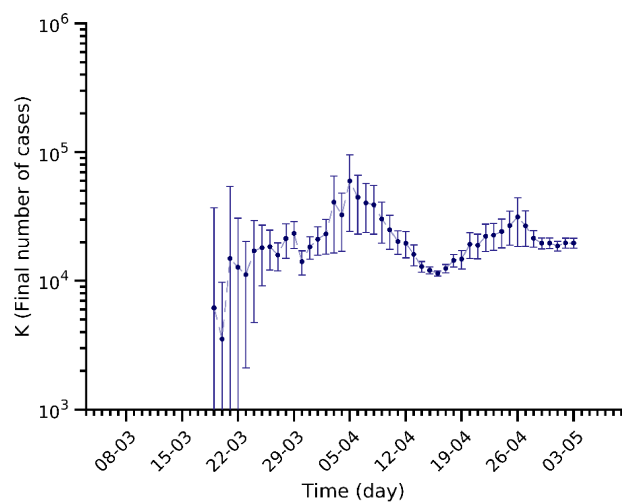
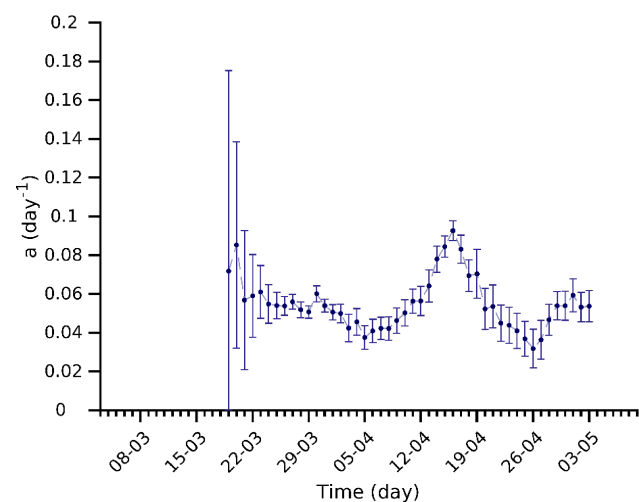
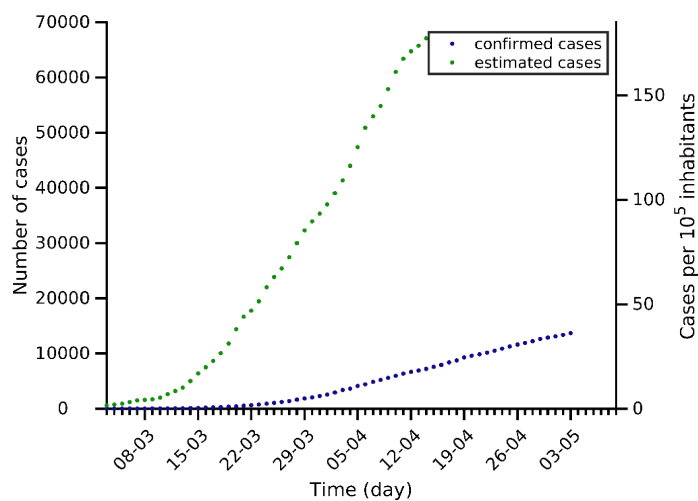
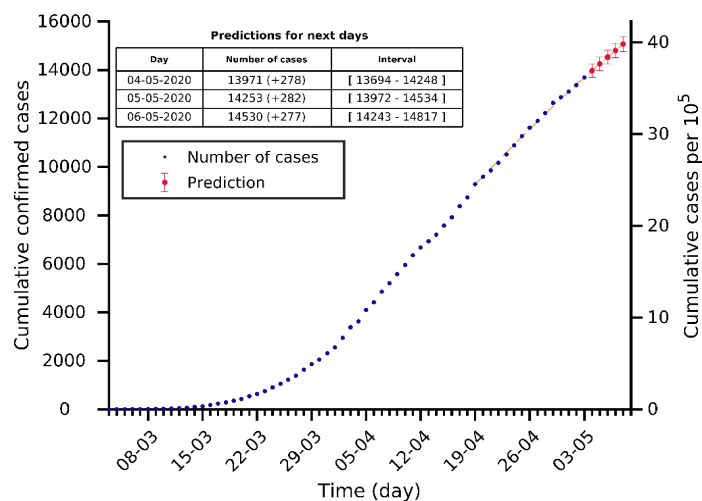
Ireland 03-05-2020. Population: 4.9M. Current cumulated incidence: 436/10⁵



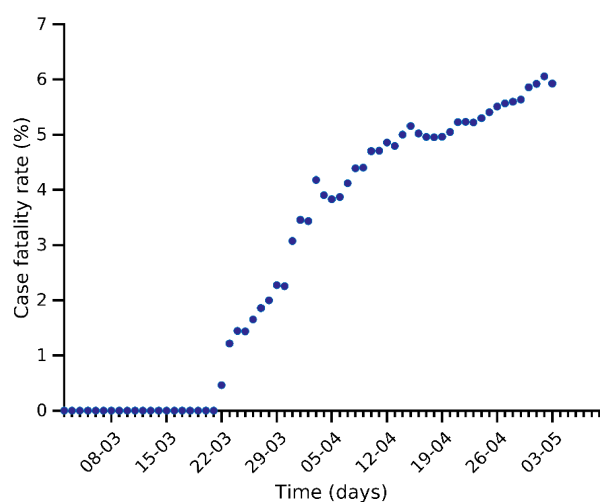
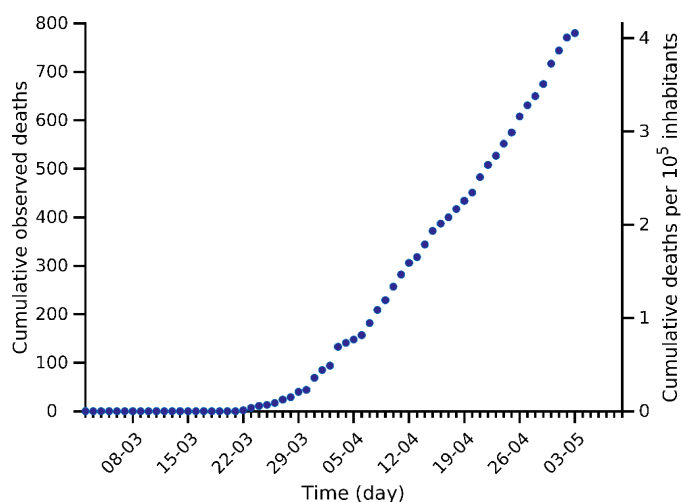
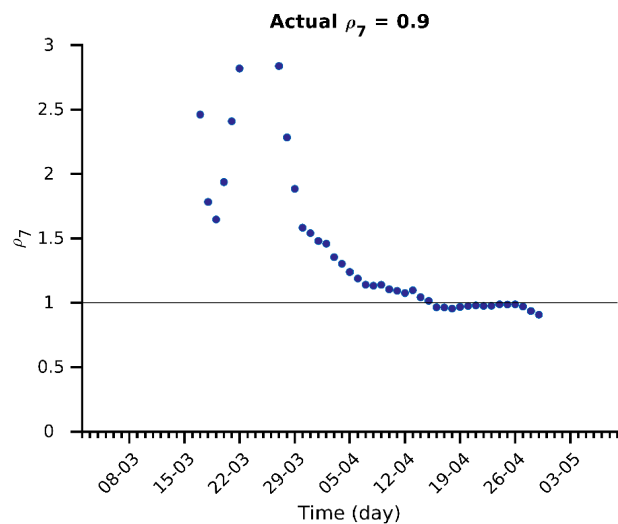
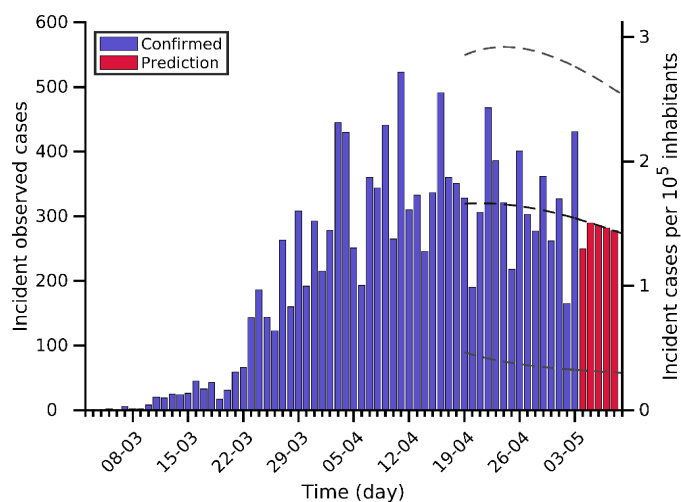
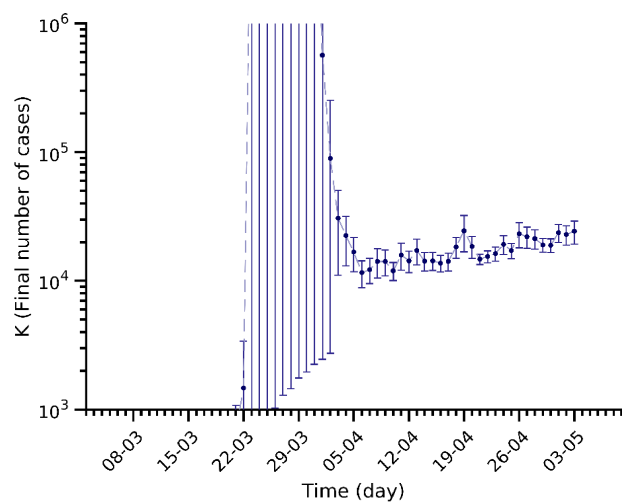
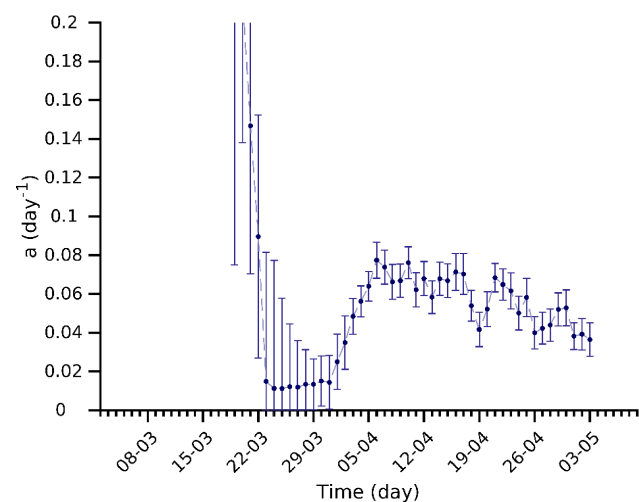
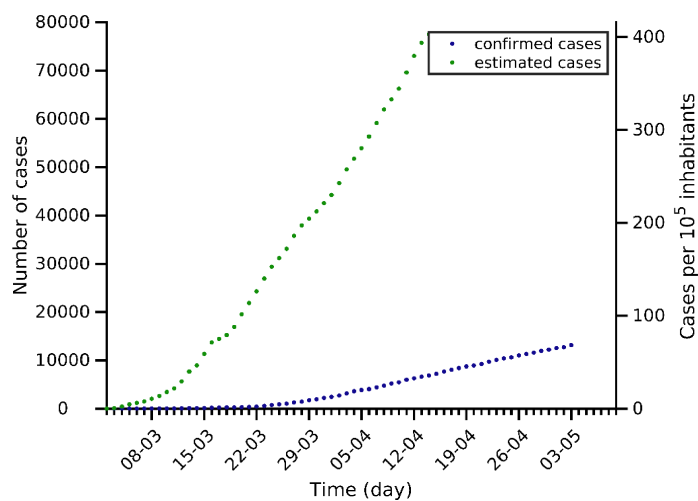
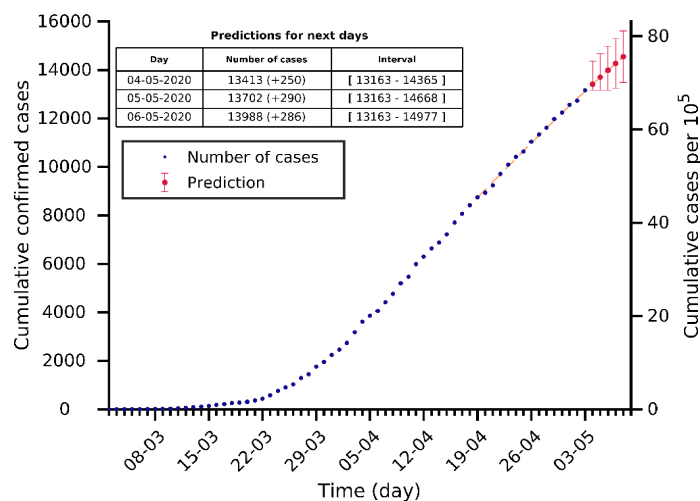
Austria 03-05-2020. Population: 9.0M. Current cumulated incidence: 173/10⁵



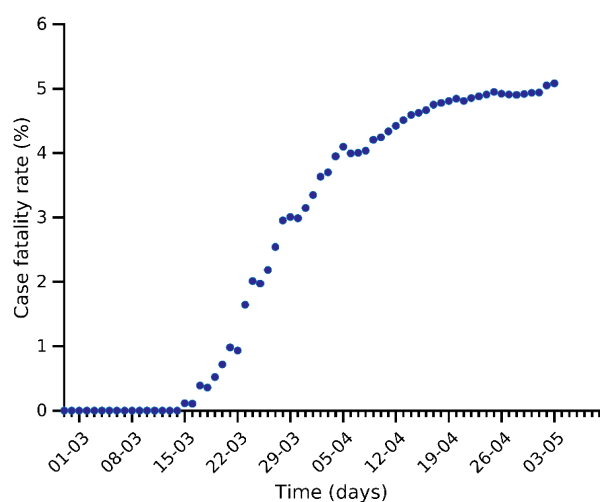
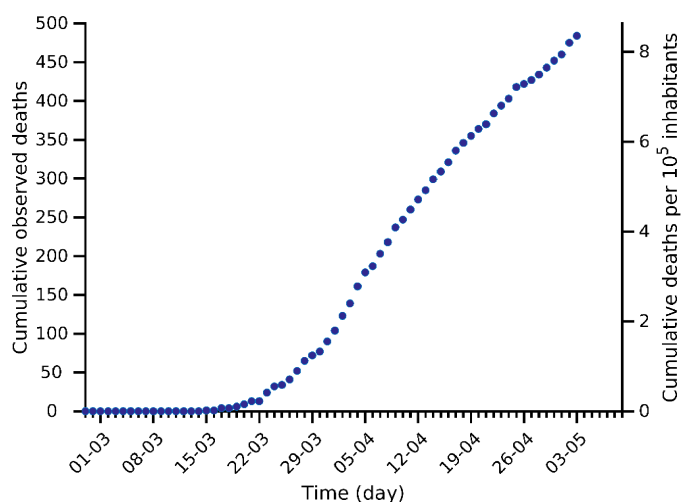
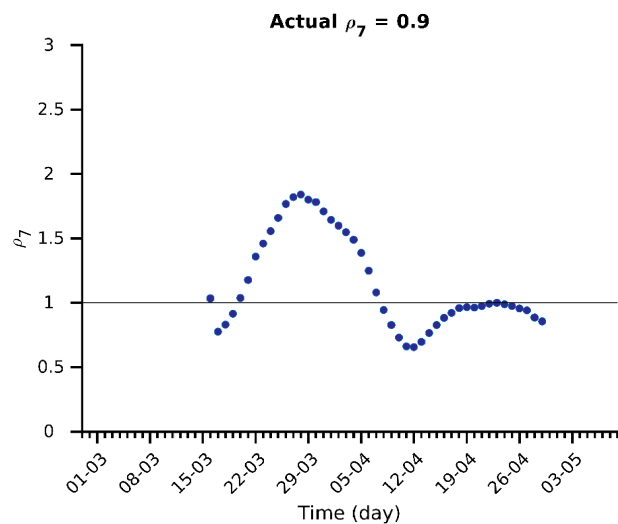
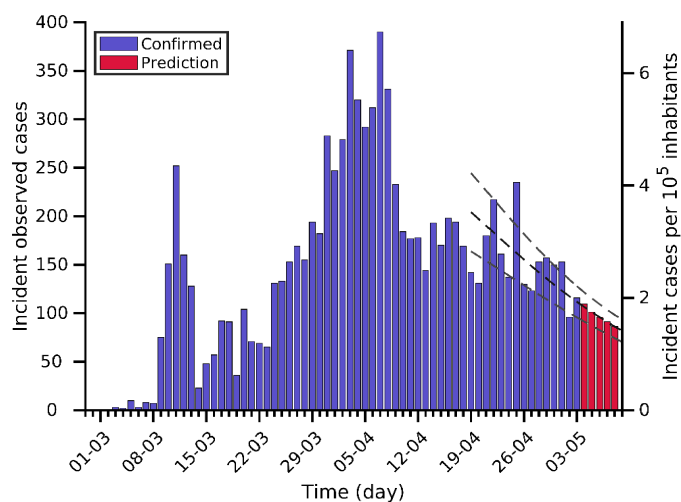
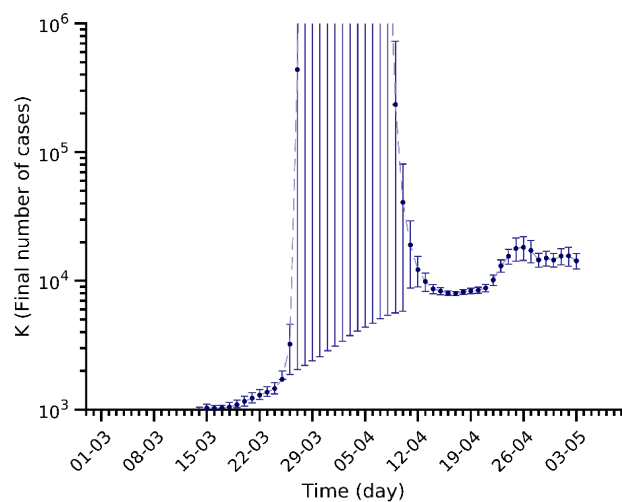
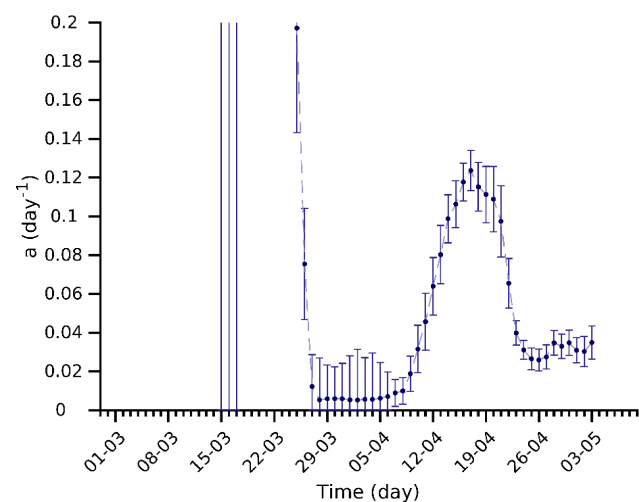
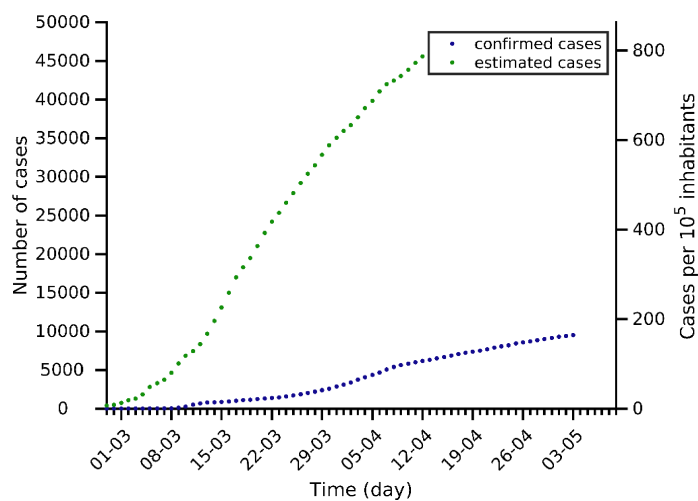
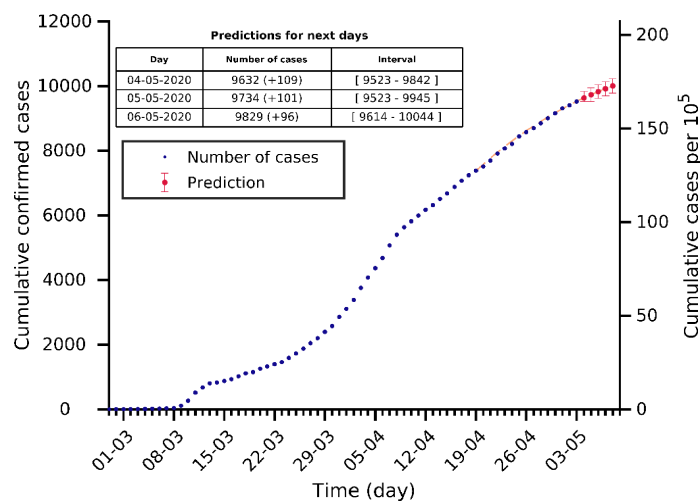
Poland 03-05-2020. Population: 37.8M. Current cumulated incidence: 36/10⁵



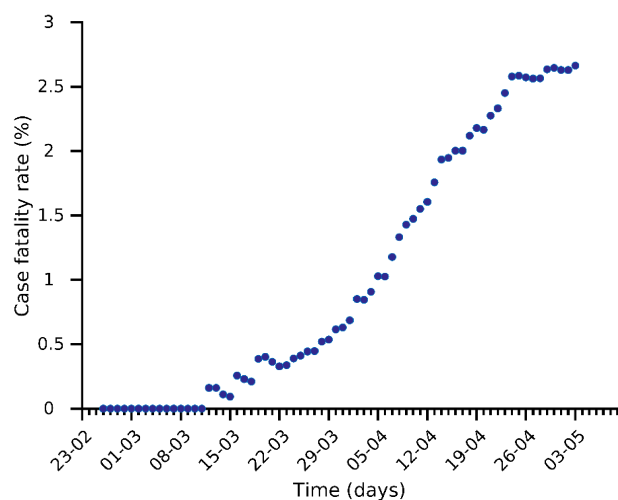
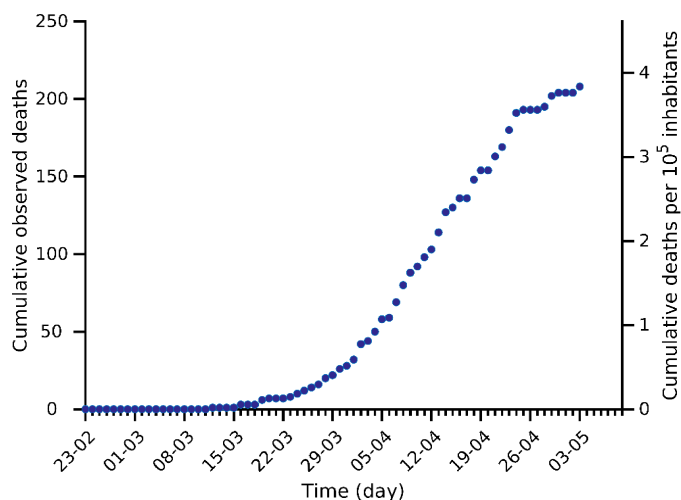
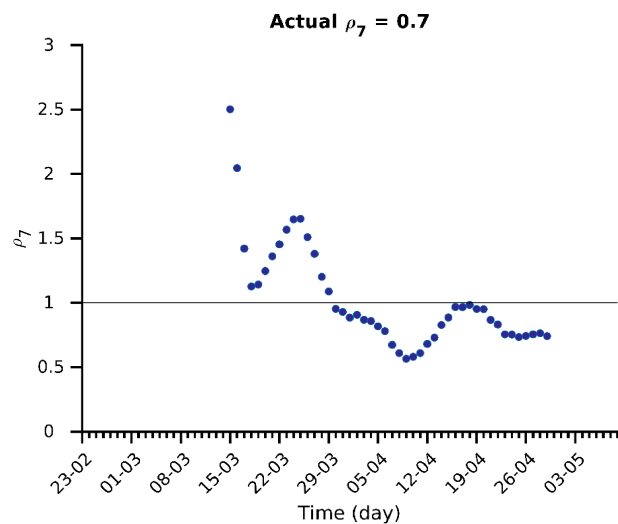
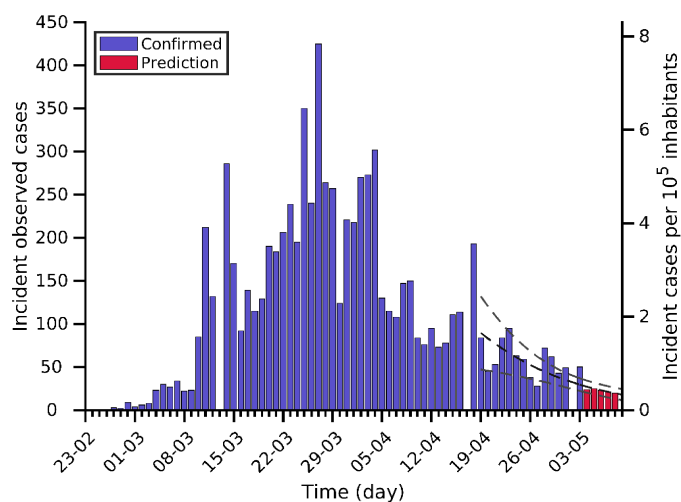
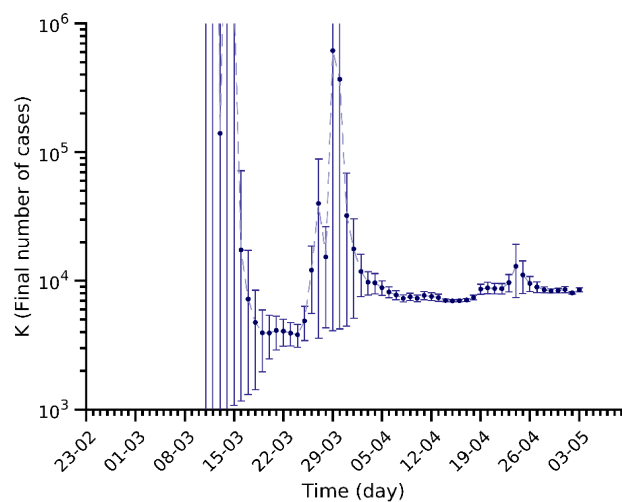
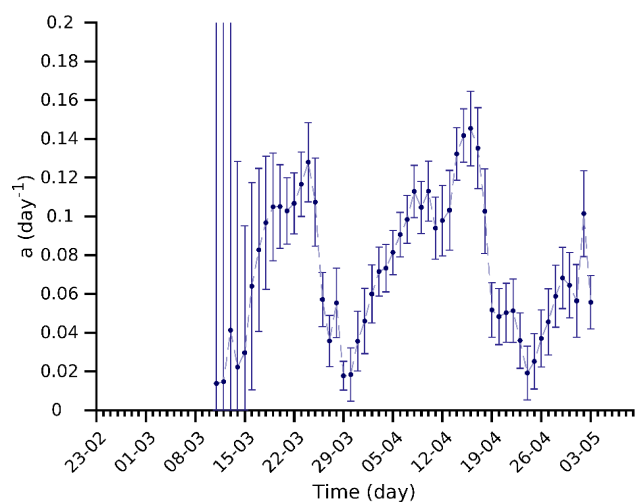
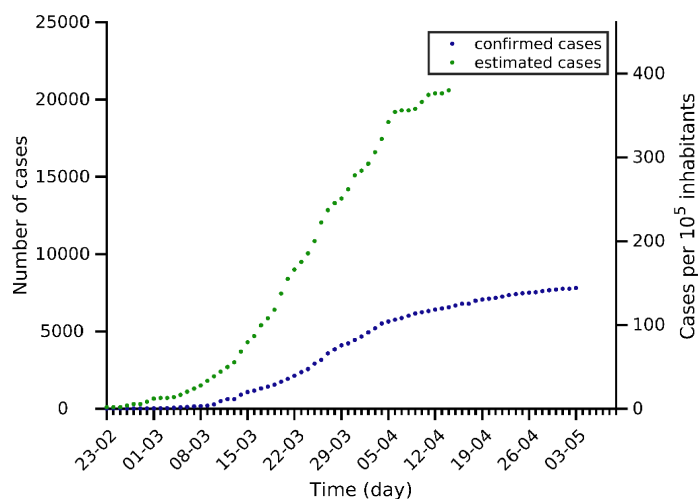
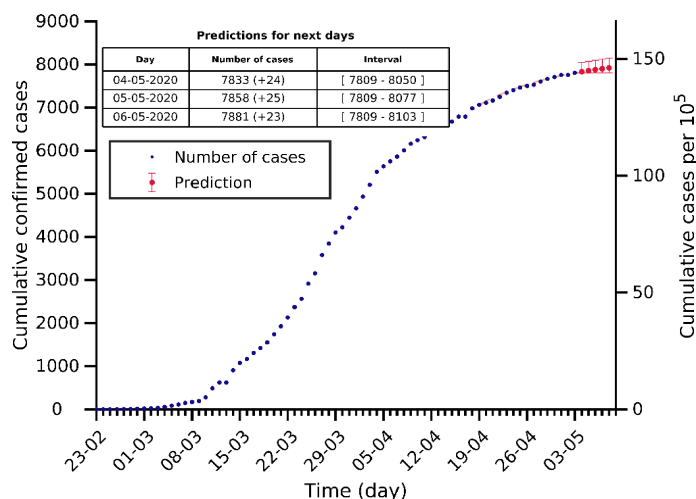
Romania 03-05-2020. Population: 19.2M. Current cumulated incidence: 68/10⁵

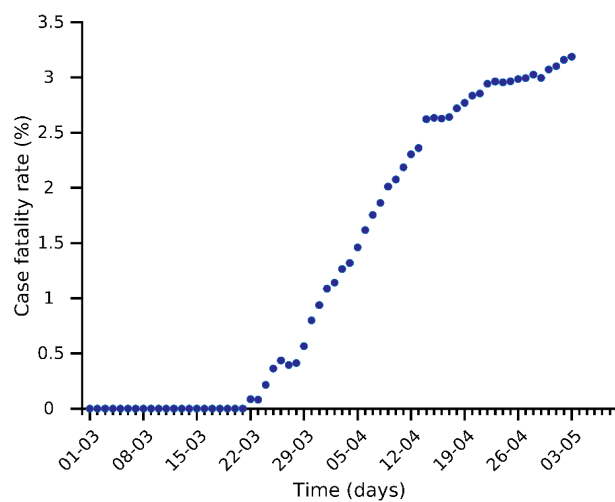
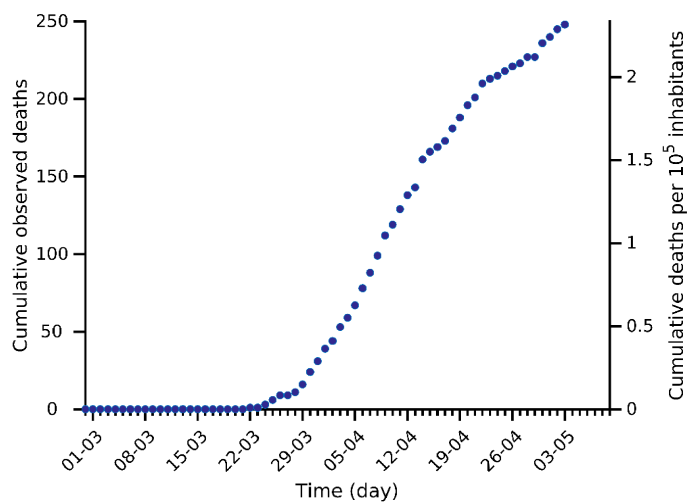
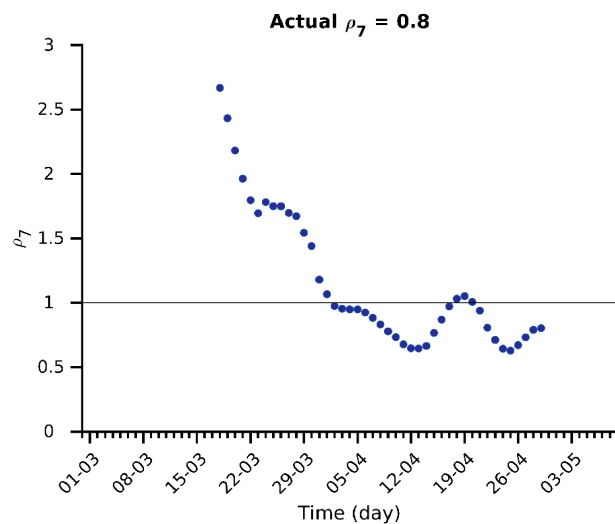
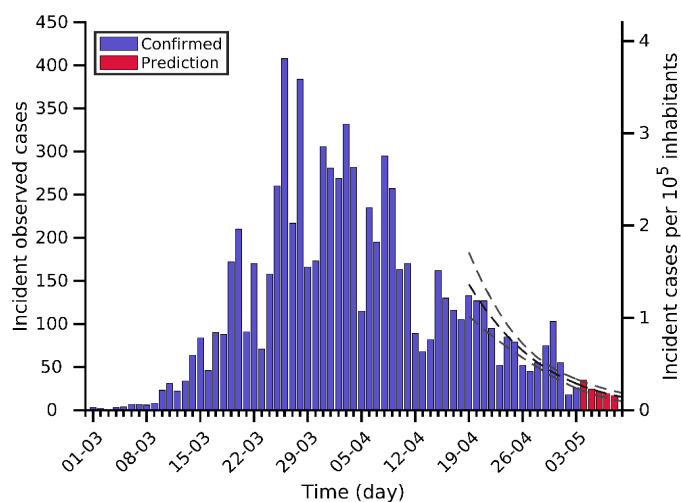
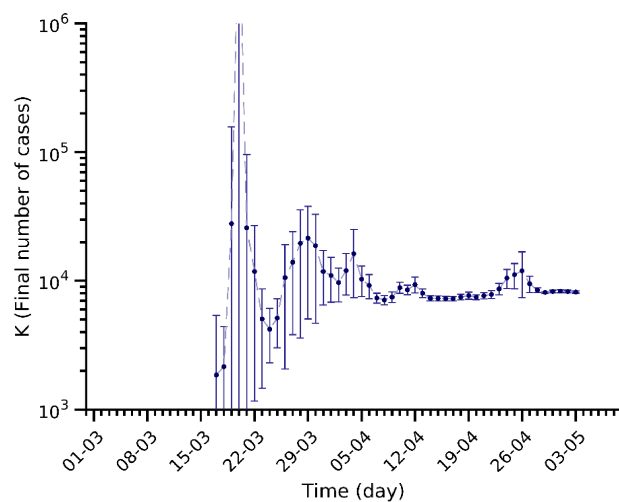
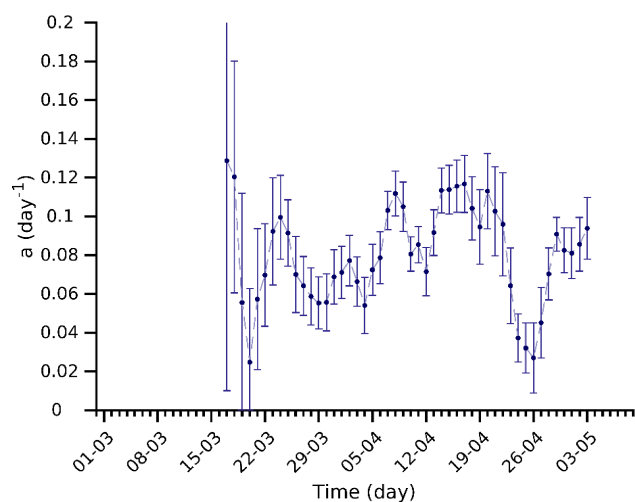
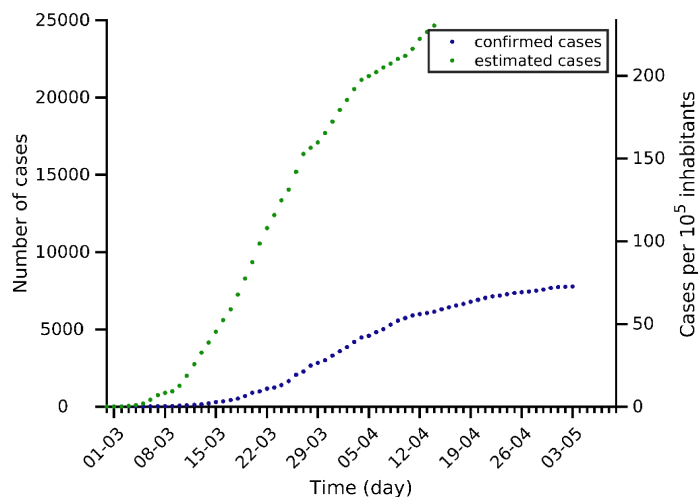
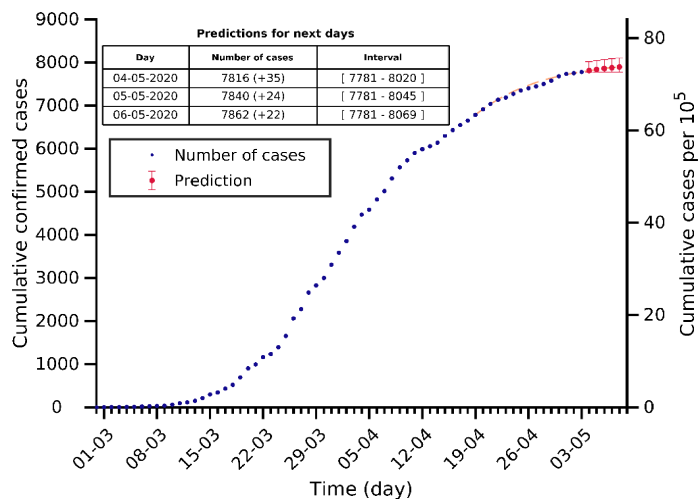


Denmark 03-05-2020. Population: 5.8M. Current cumulated incidence: 164/10⁵

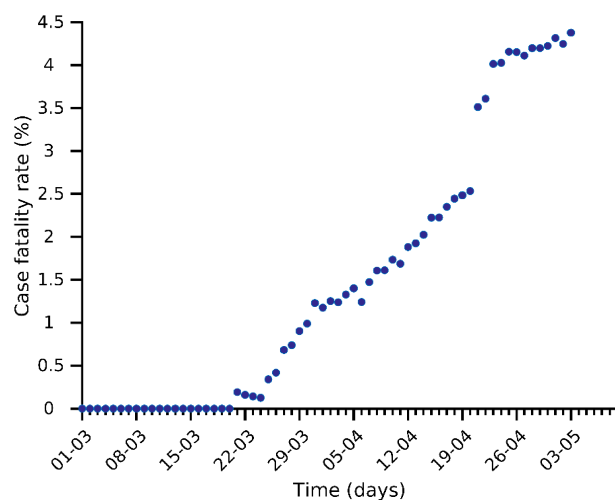
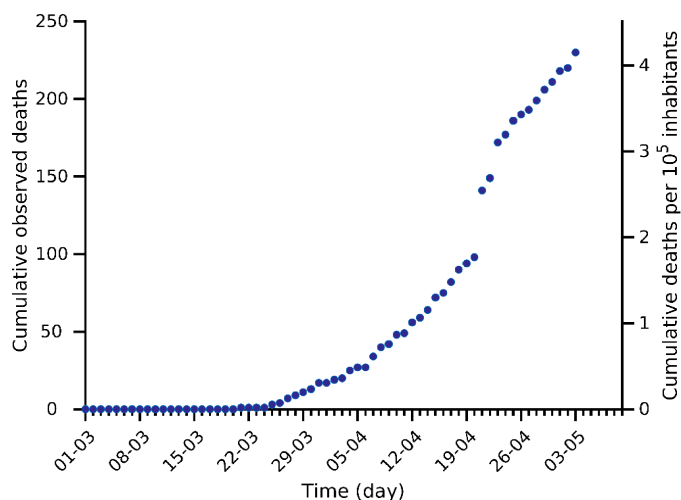
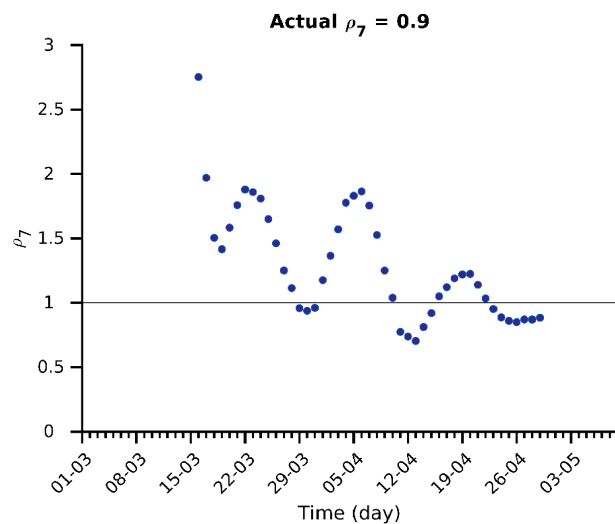
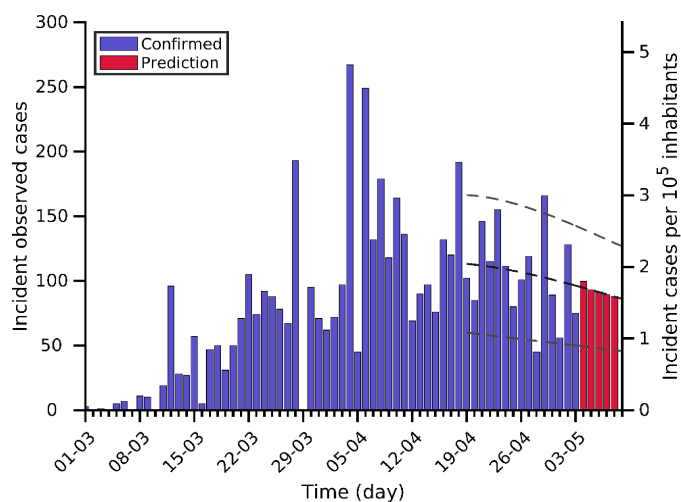
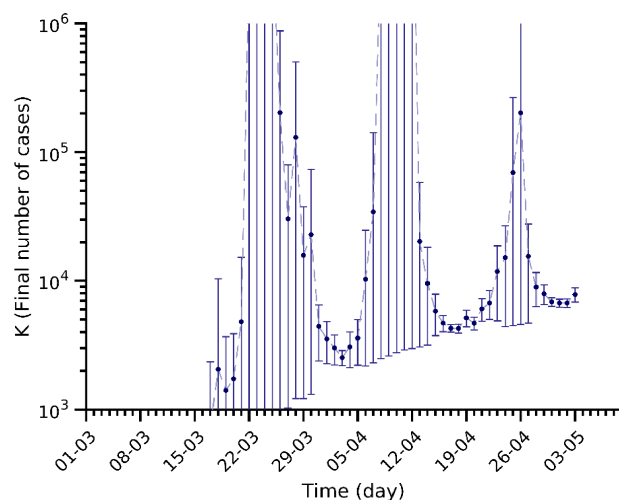
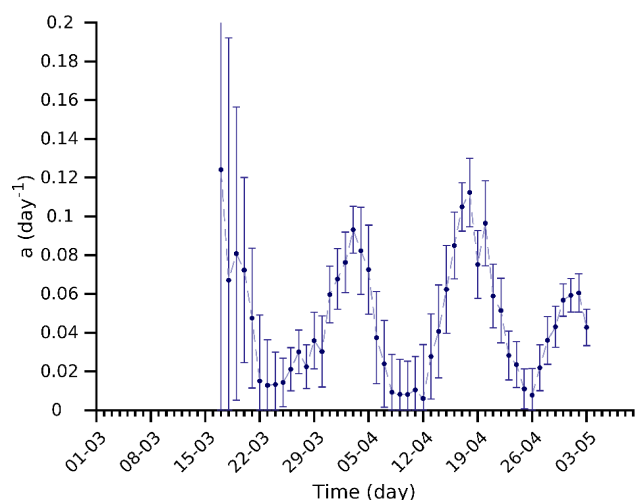
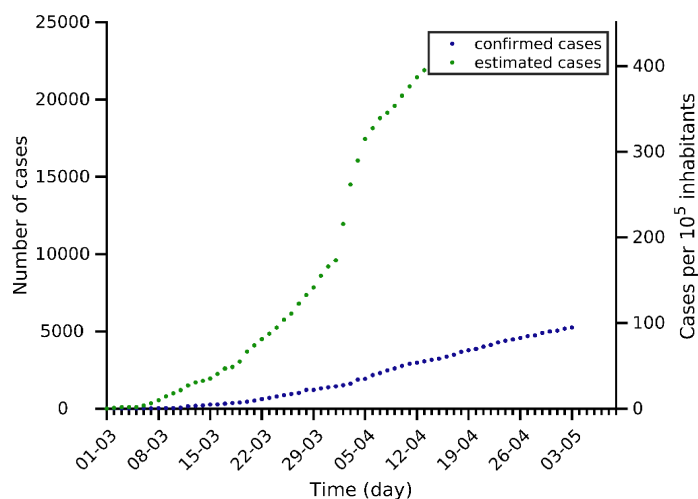
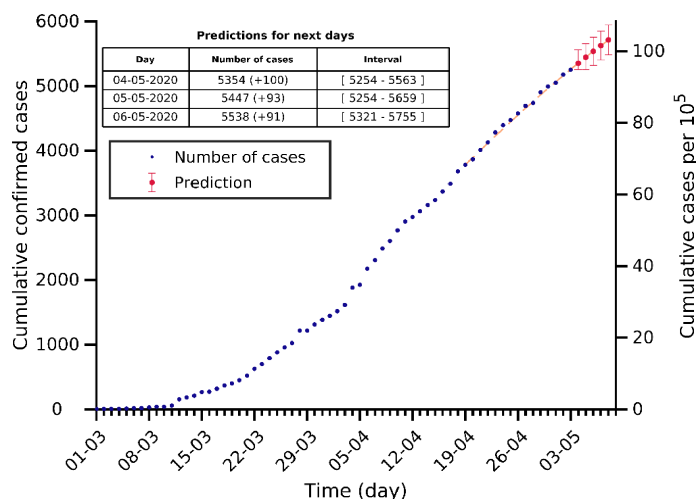


Norway 03-05-2020. Population: 5.4M. Current cumulated incidence: 144/10⁵

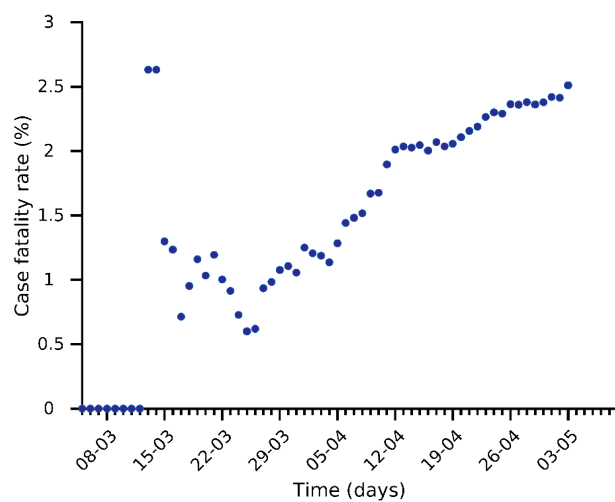
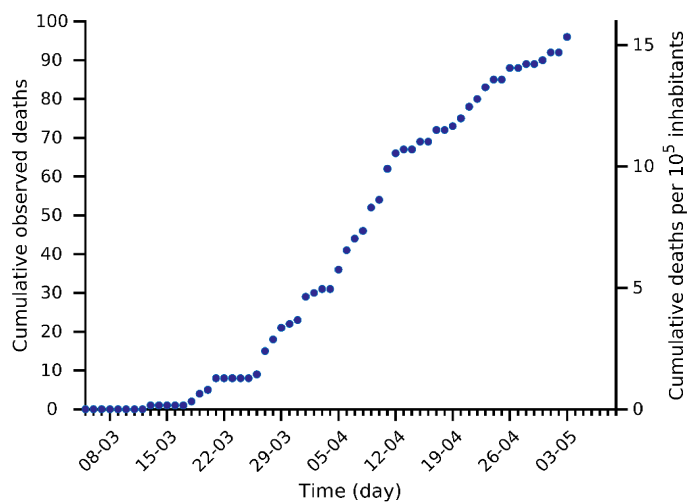
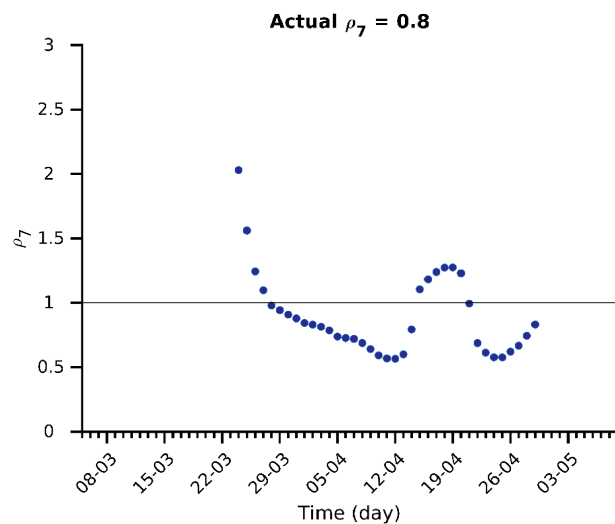
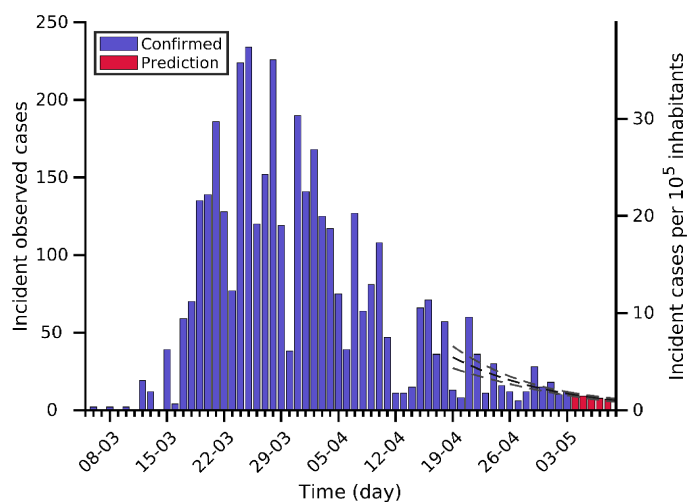
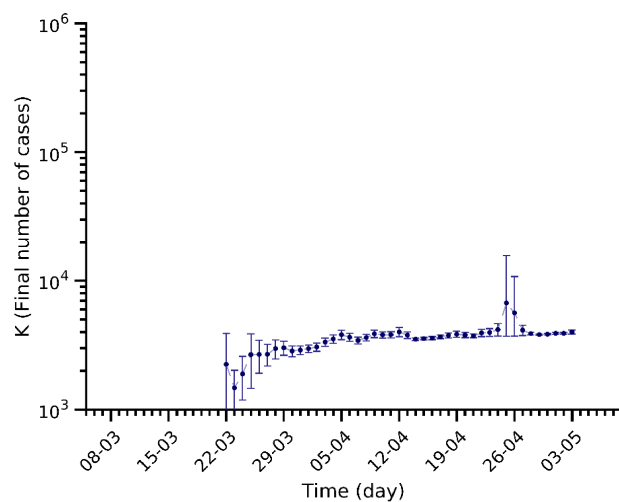
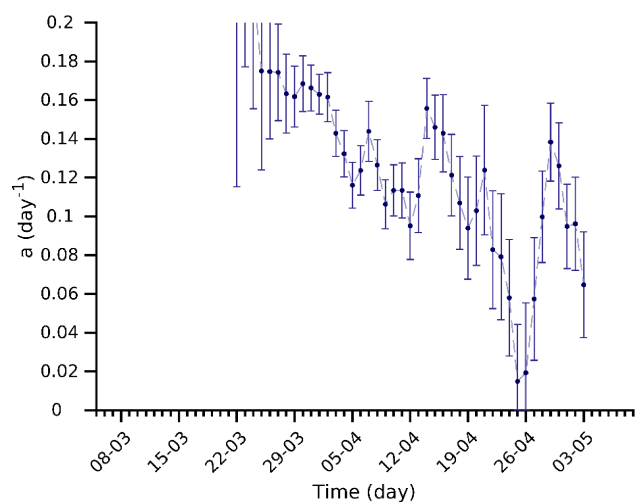
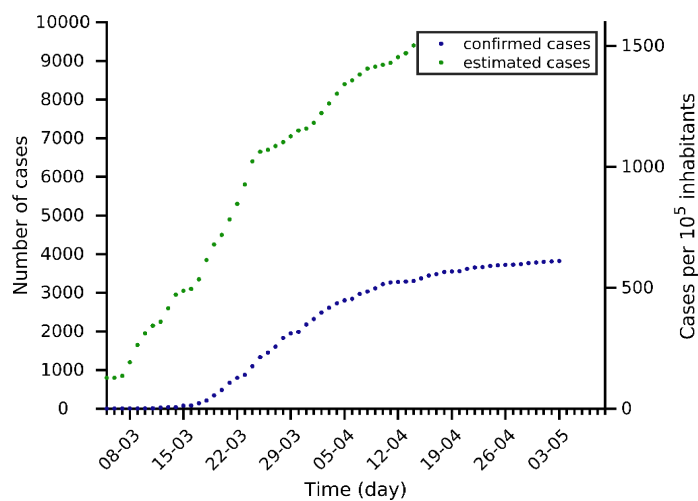
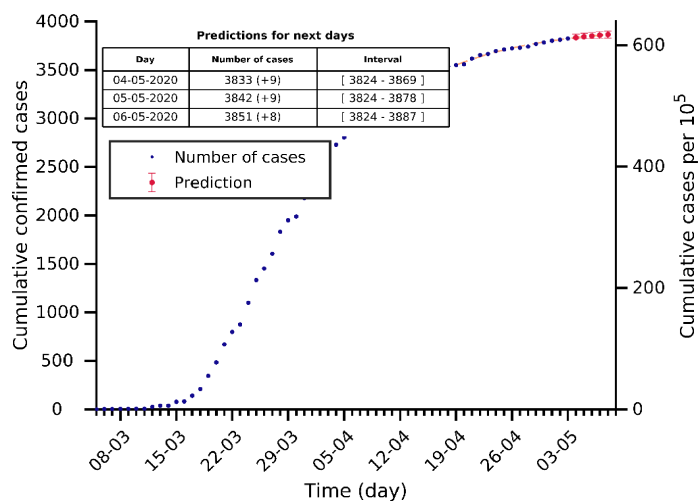




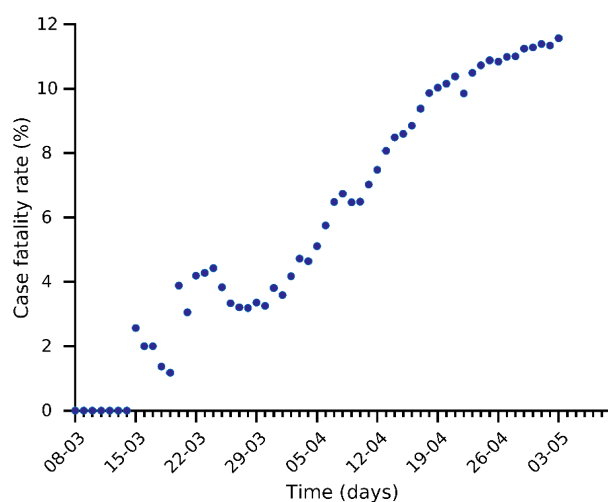
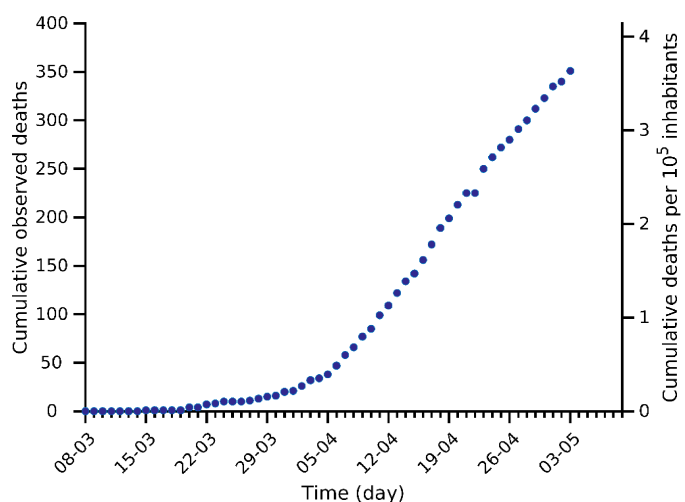
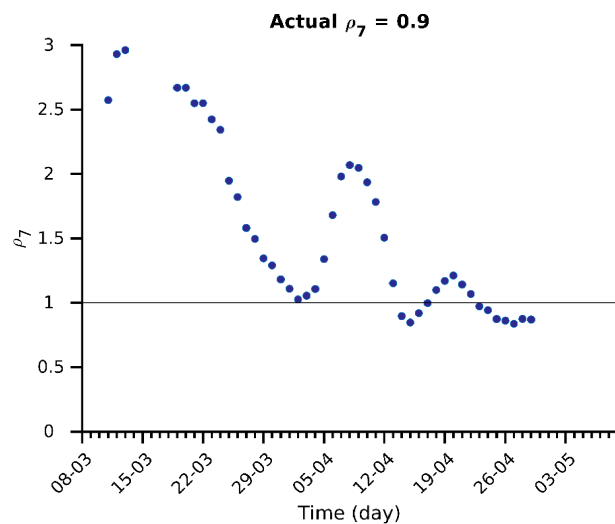
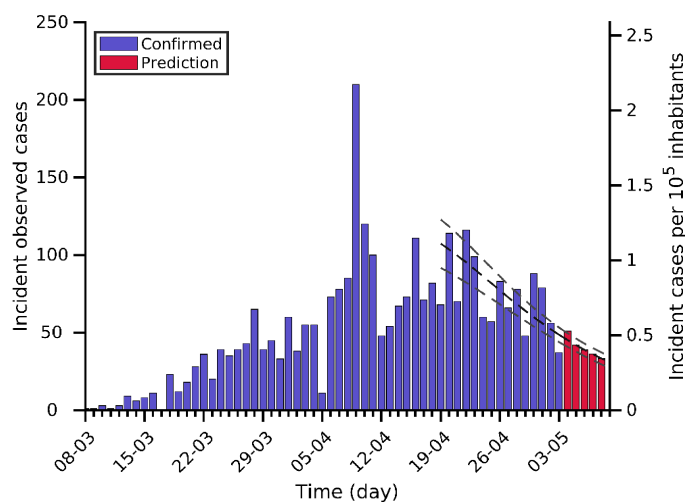
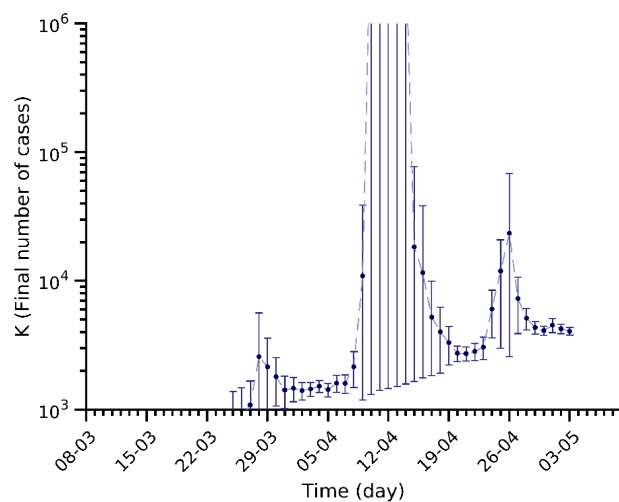
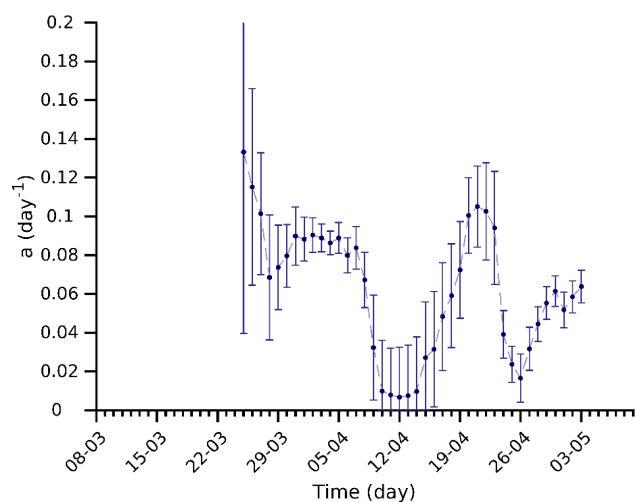
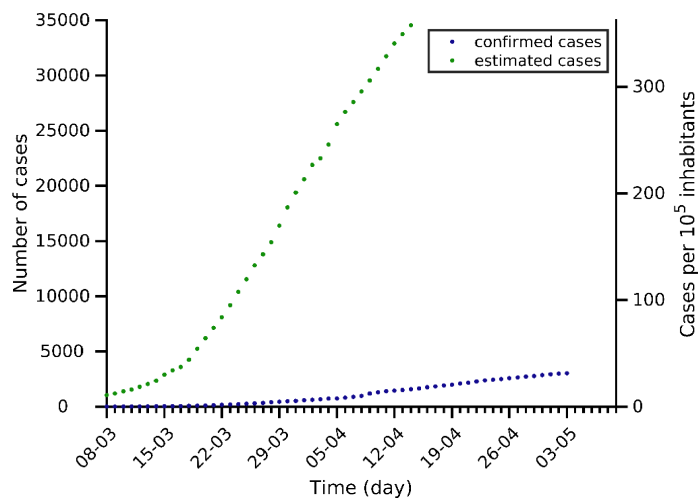
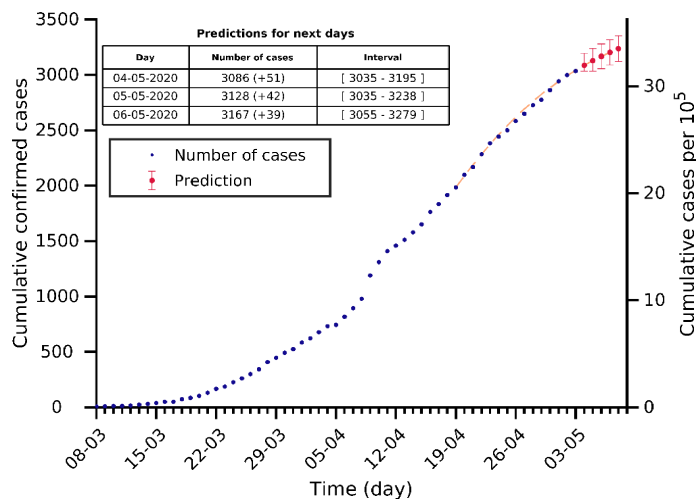
Finland 03-05-2020. Population: 5.5M. Current cumulated incidence: 95/10⁵



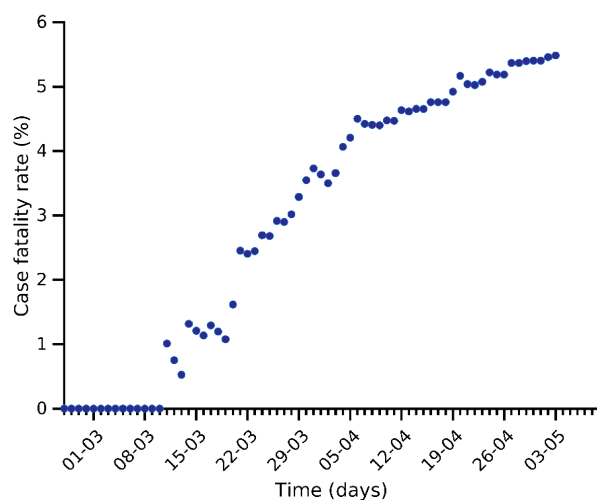
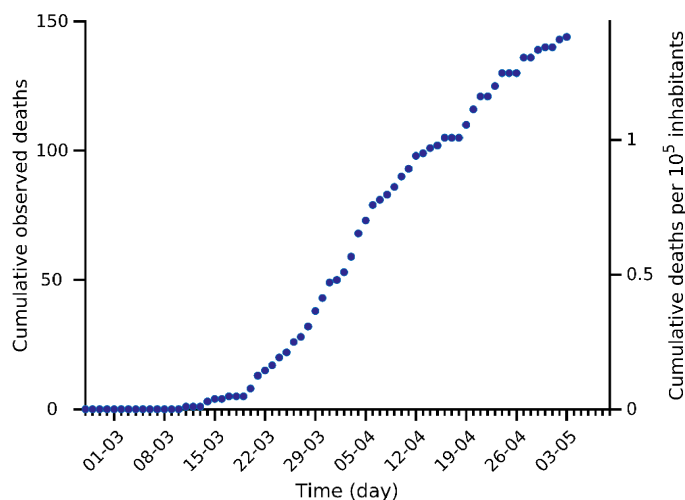
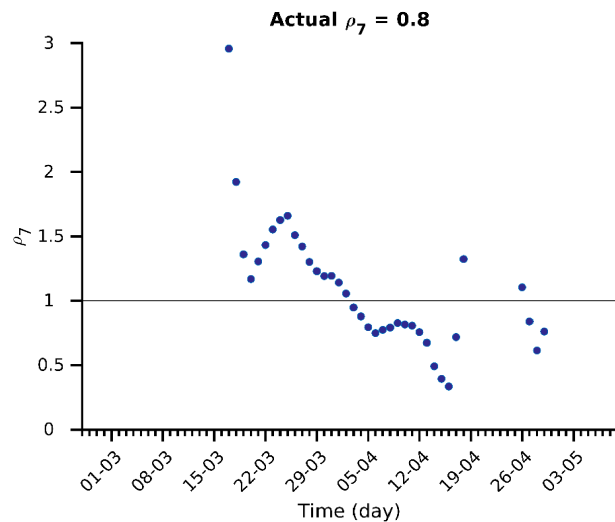
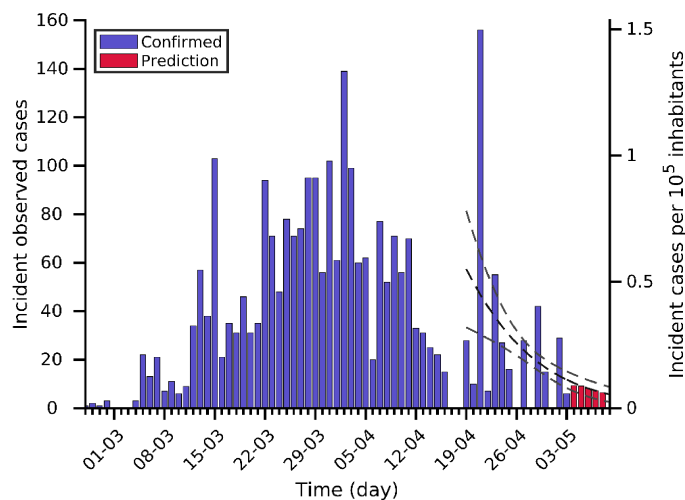
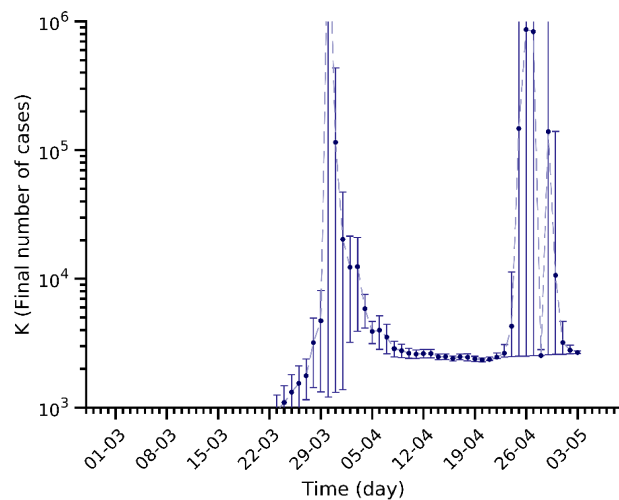
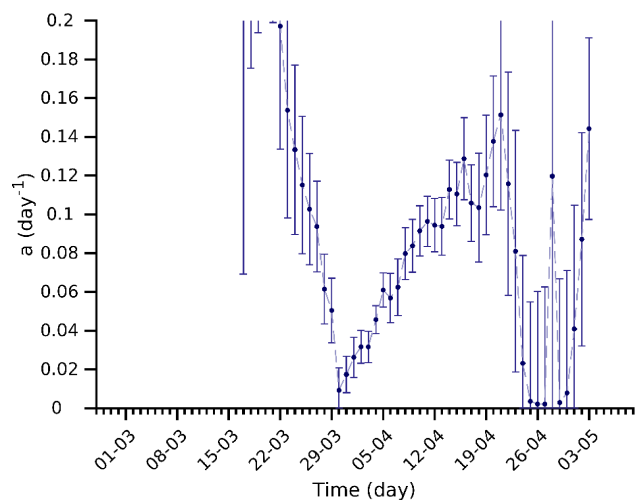
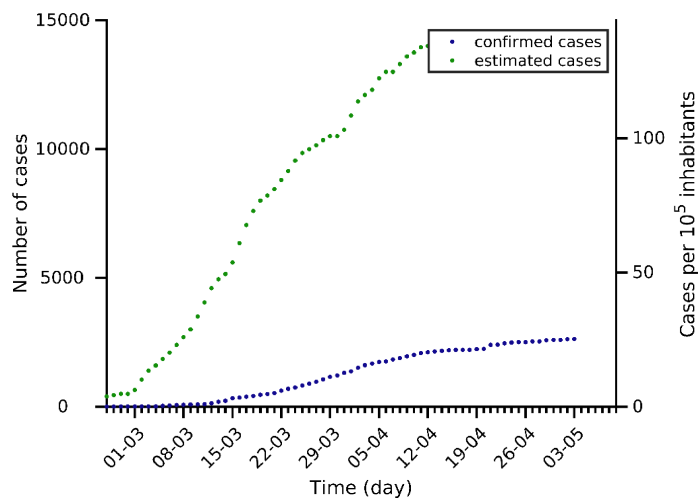
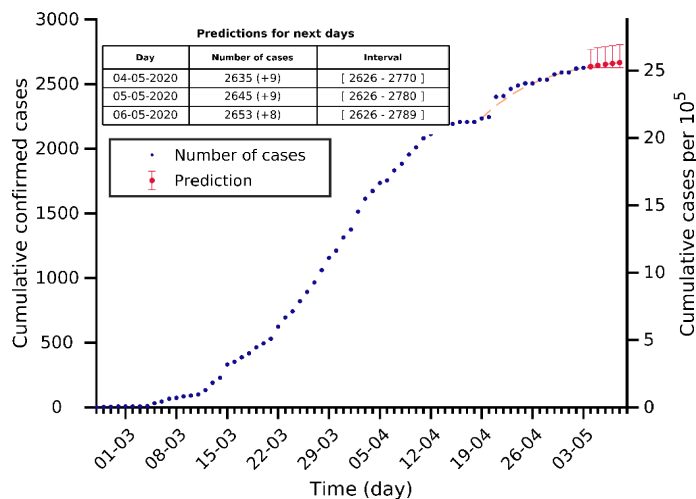
Luxembourg 03-05-2020. Population: 0.6M. Current cumulated incidence: 611/10⁵



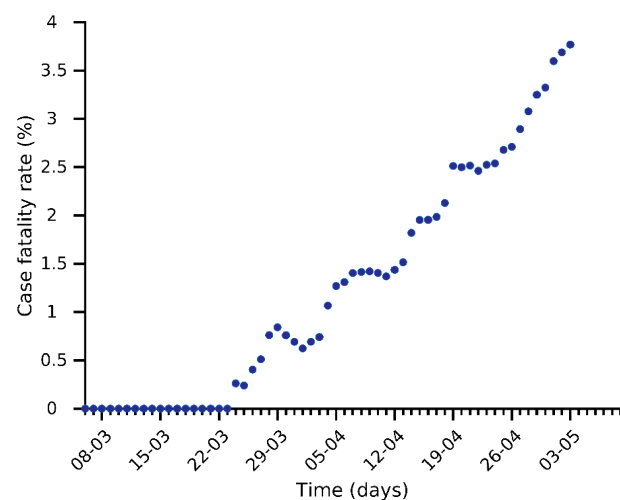
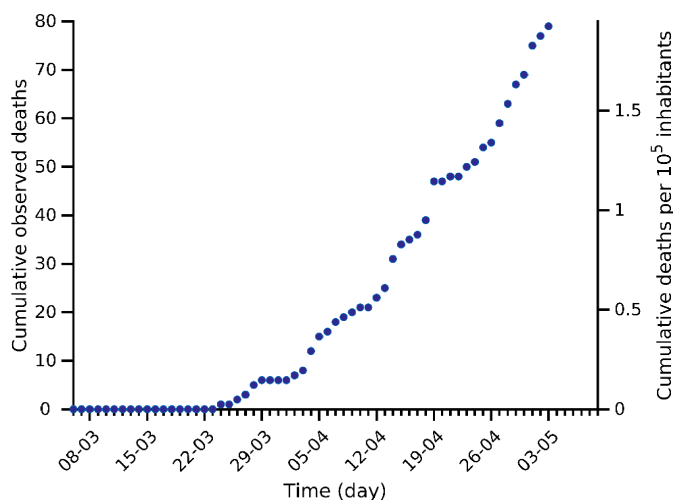
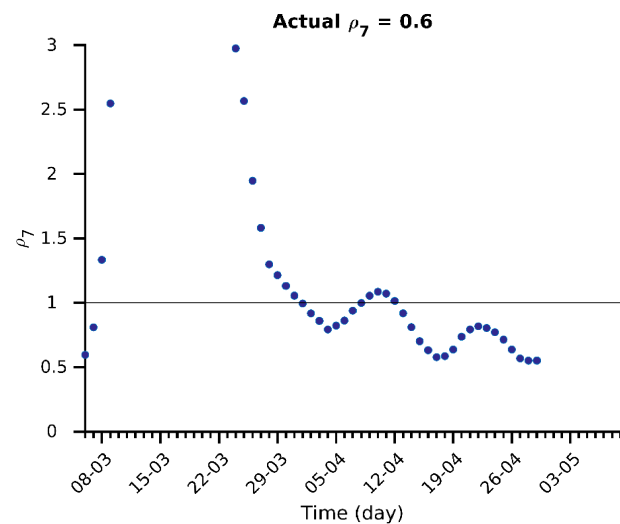
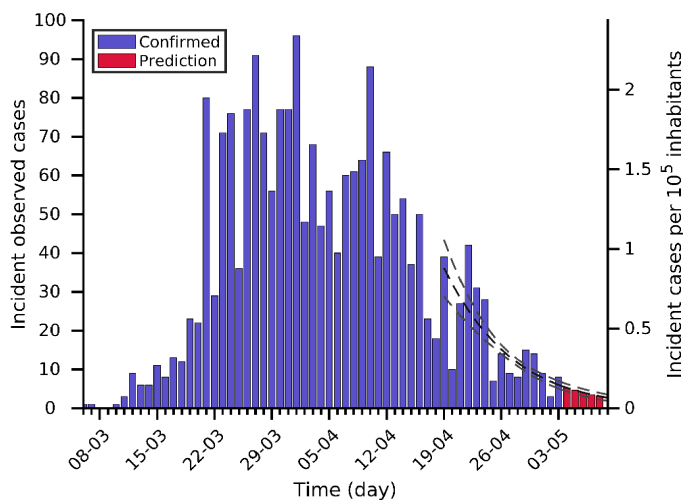
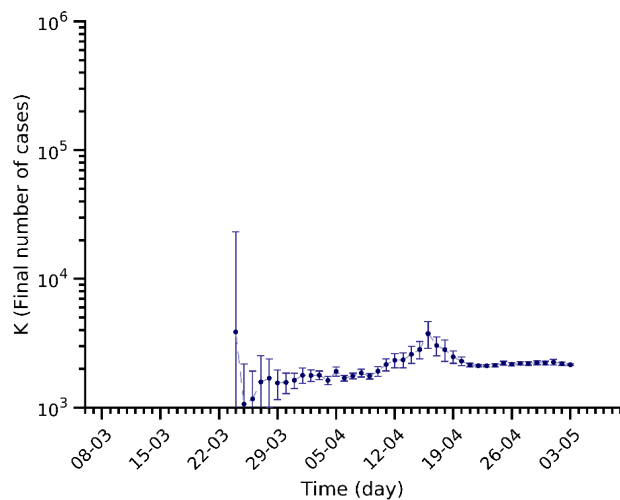
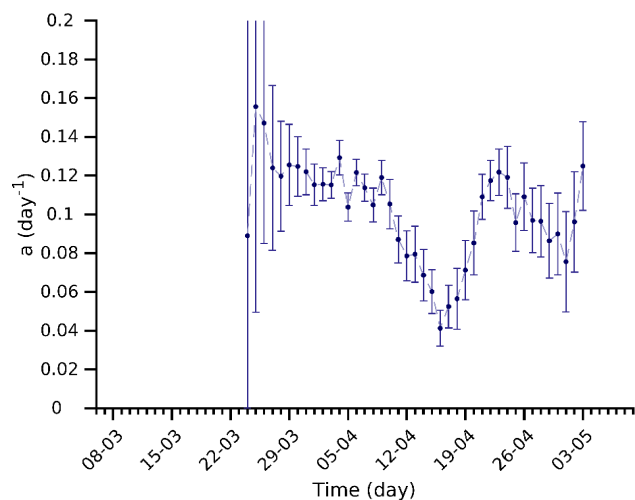
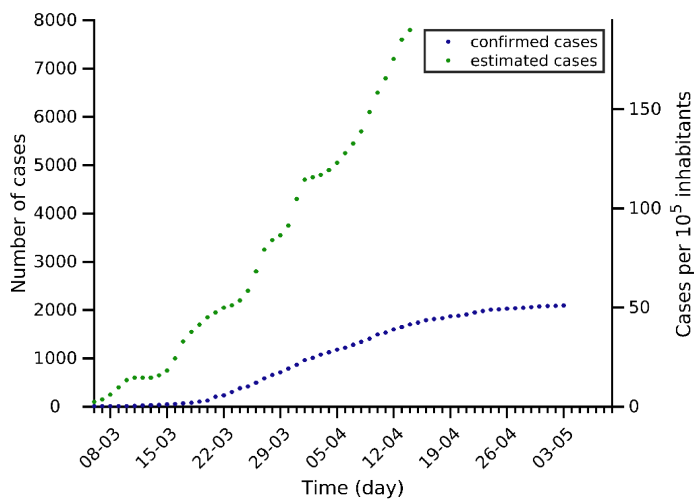
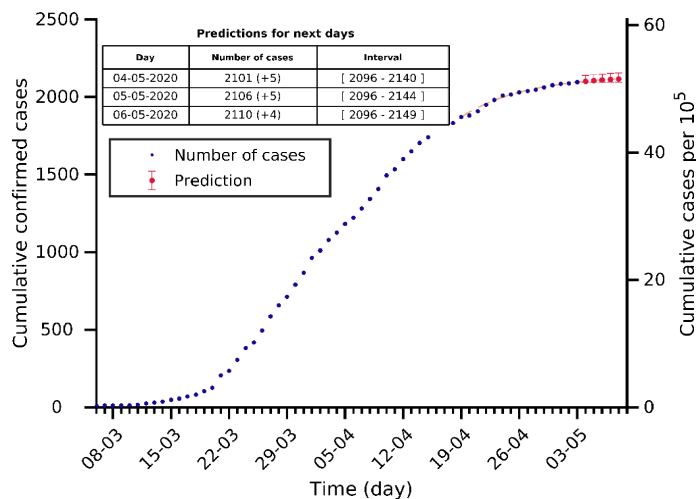
Hungary 03-05-2020. Population: 9.7M. Current cumulated incidence: 31/10⁵



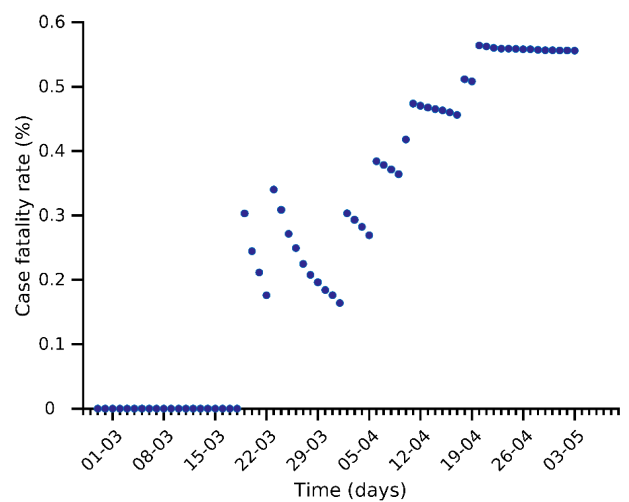
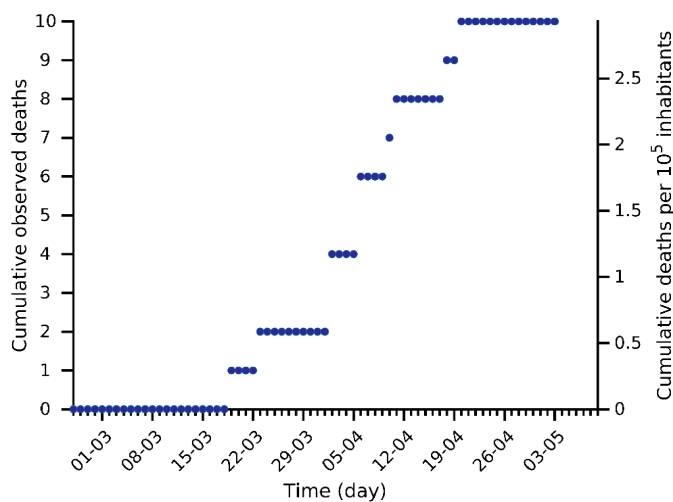
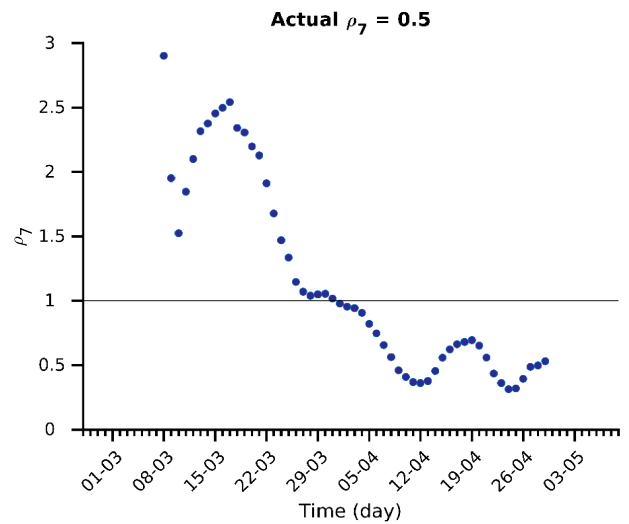
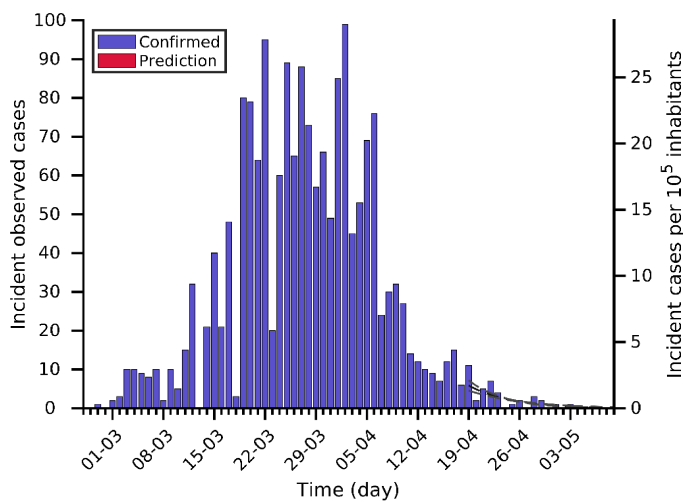
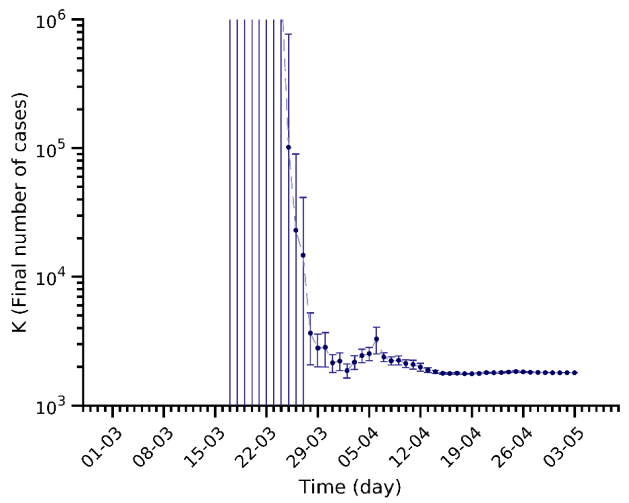
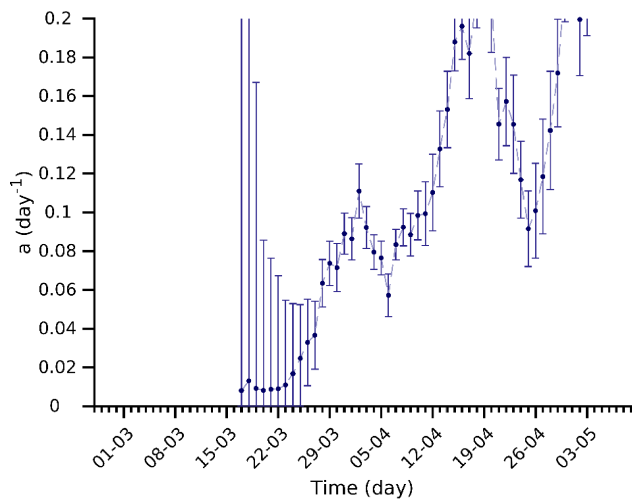
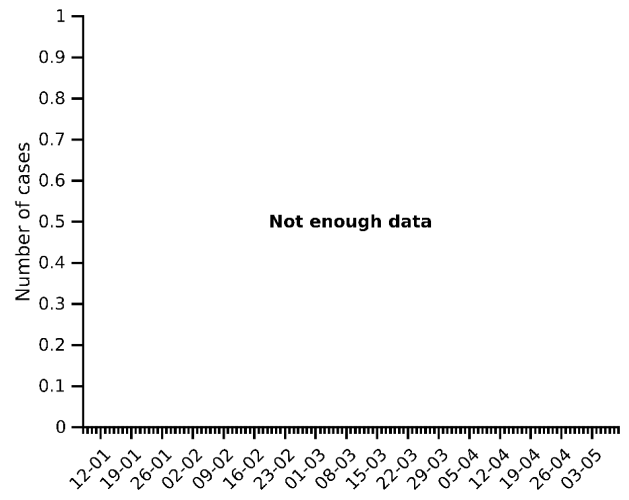
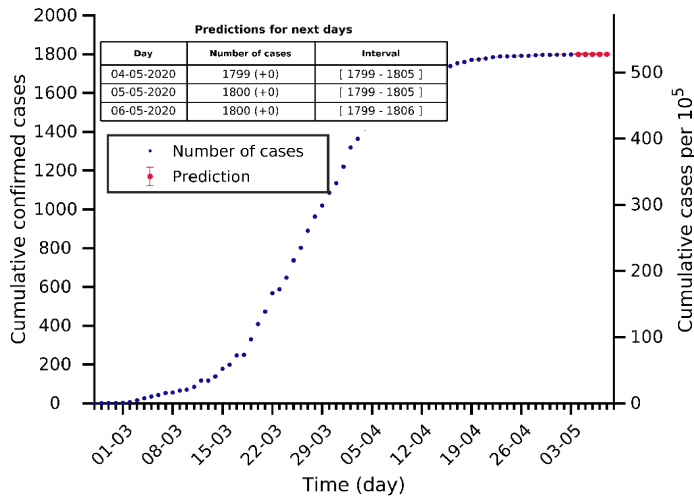
Greece 03-05-2020. Population: 10.4M. Current cumulated incidence: 25/10⁵



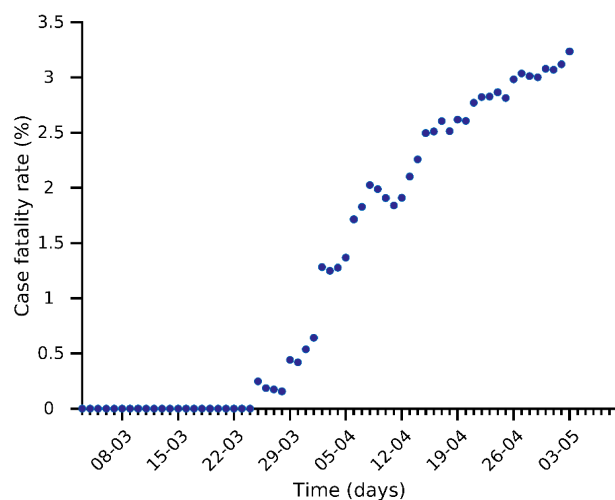
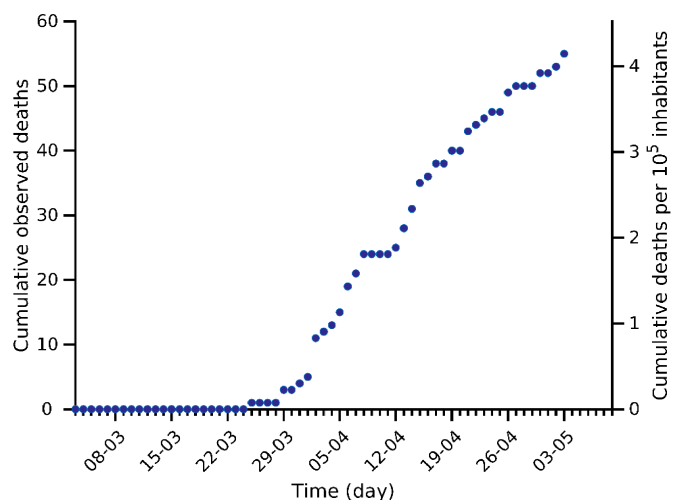
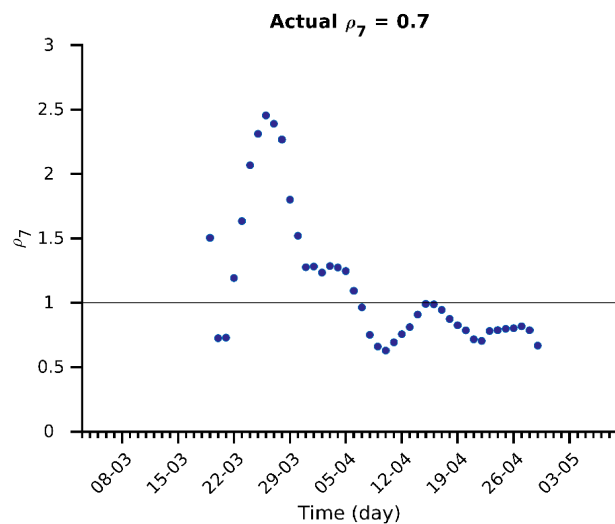
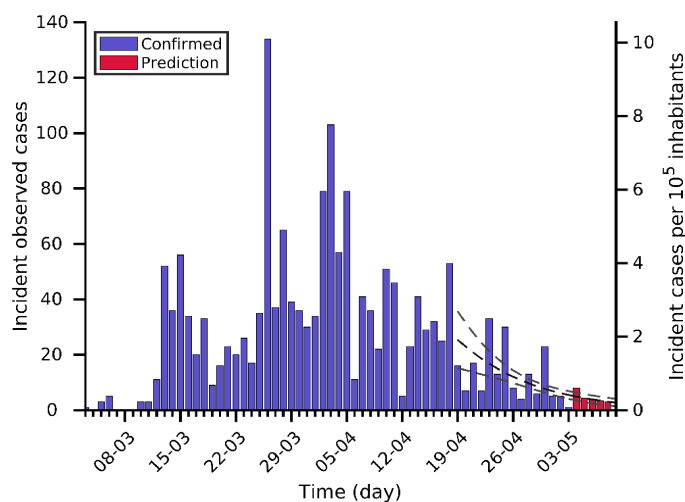
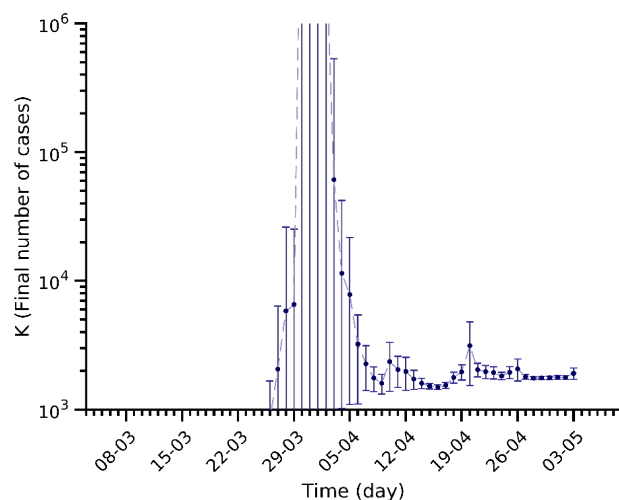
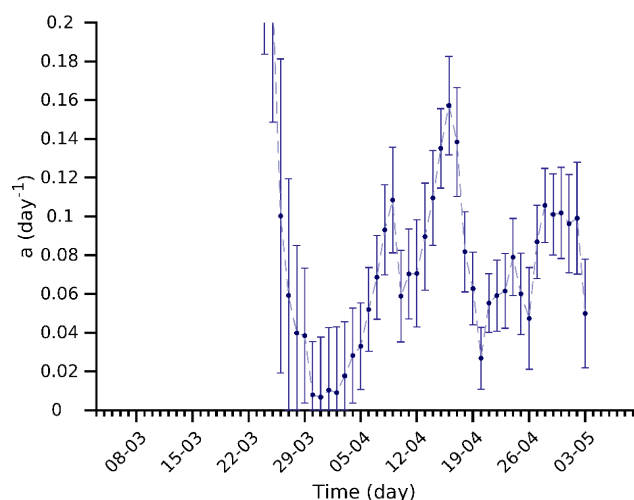
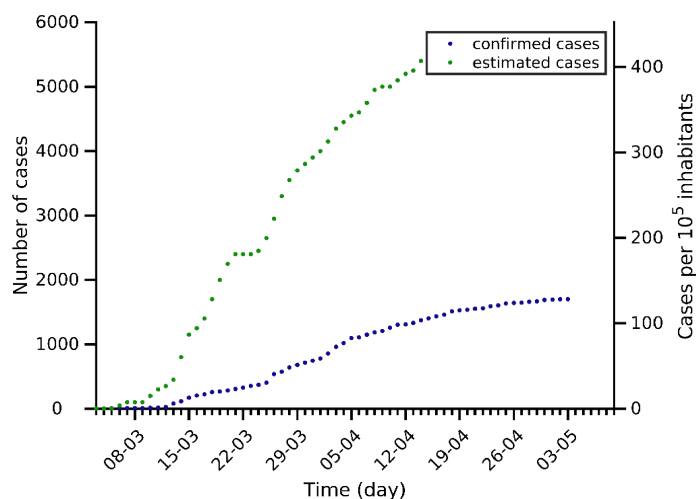
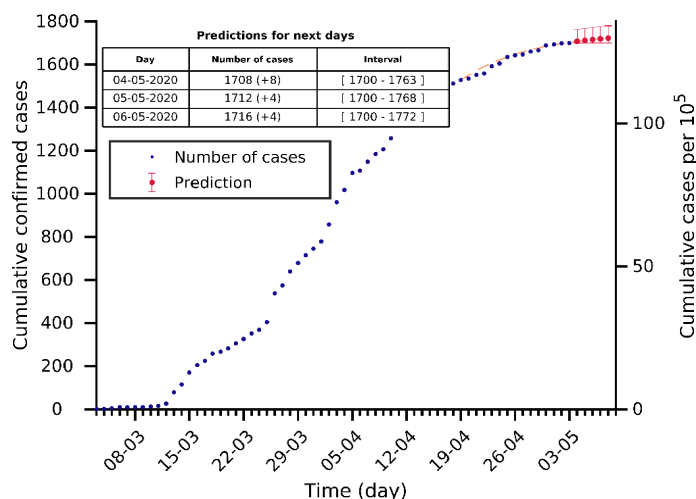
Croatia 03-05-2020. Population: 4.1M. Current cumulated incidence: 51/10⁵



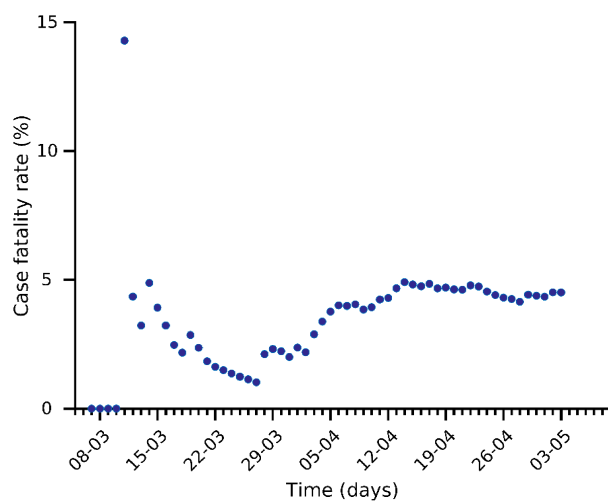
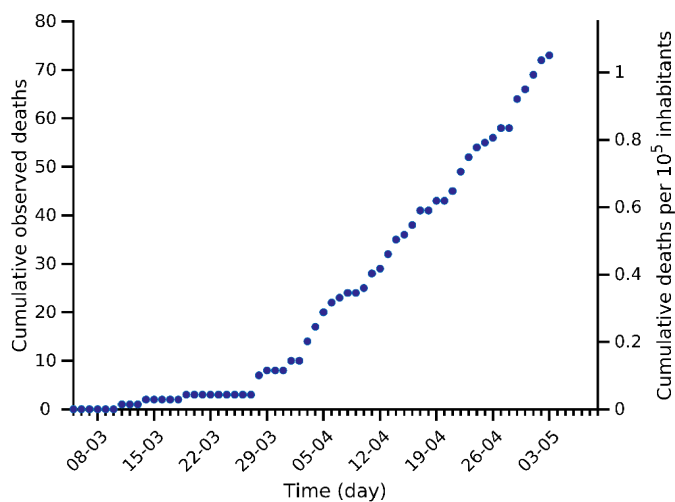
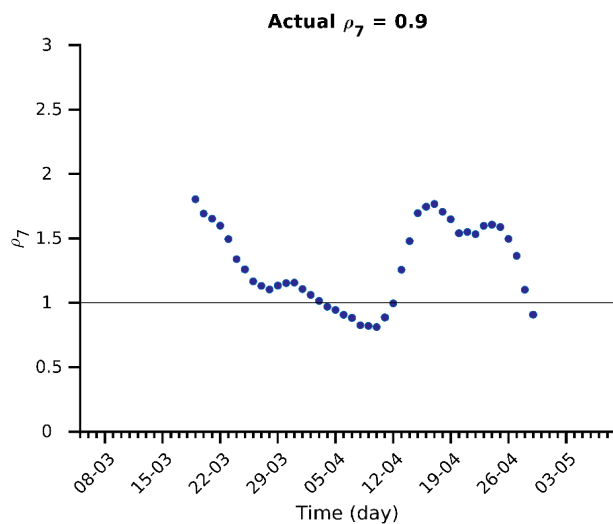
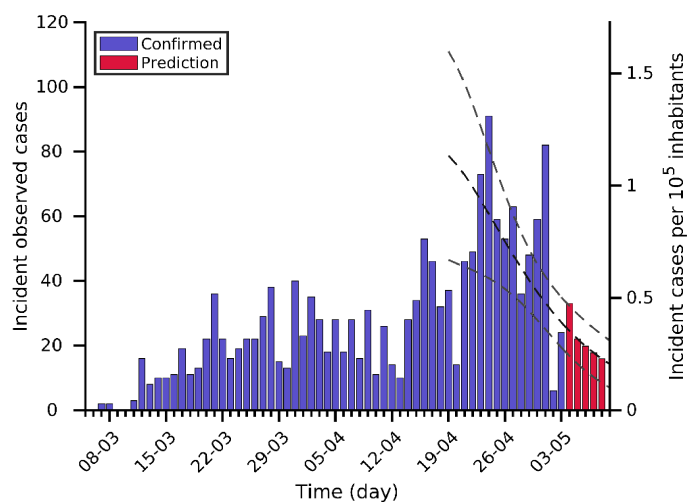
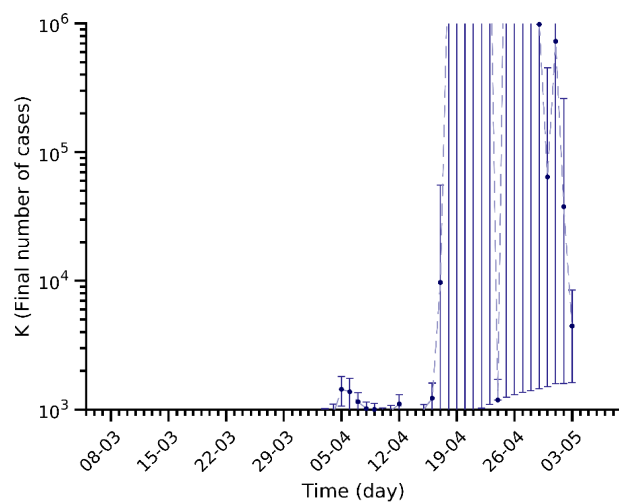
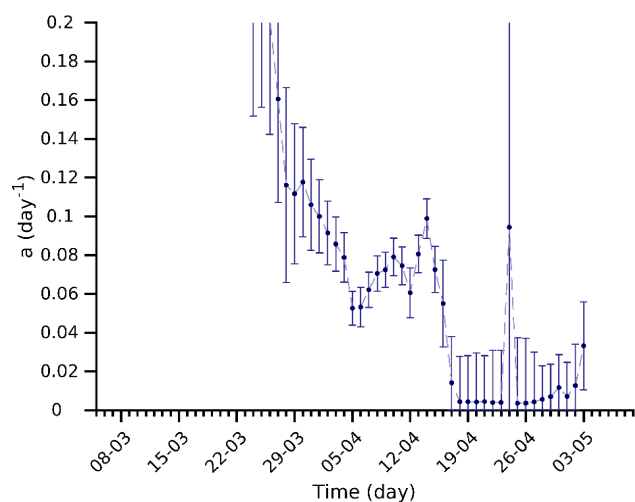
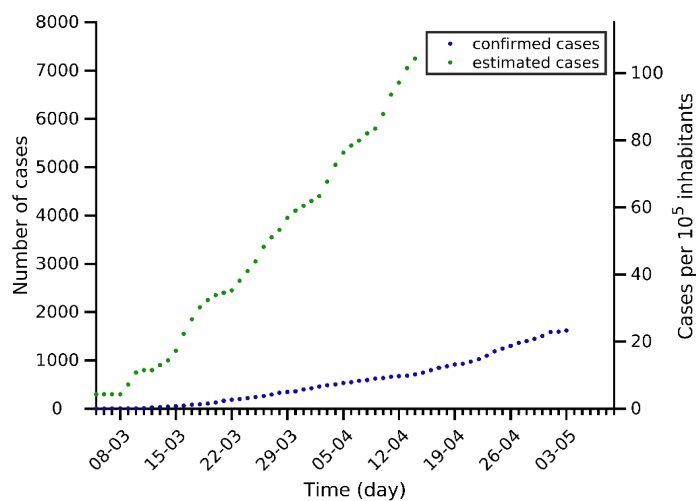
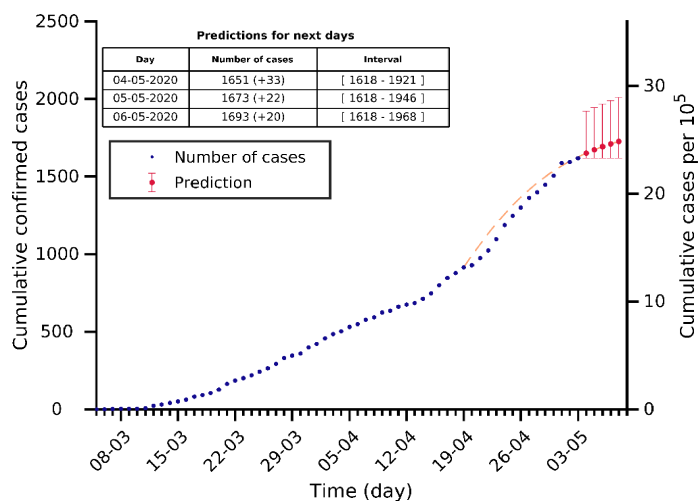
Iceland 03-05-2020. Population: 0.3M. Current cumulated incidence: 527/10⁵



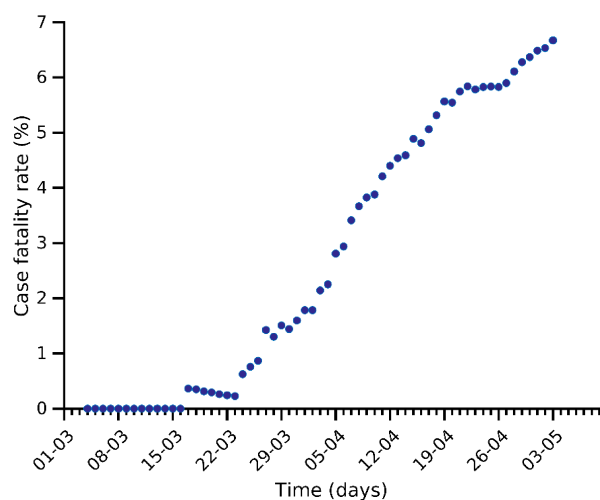
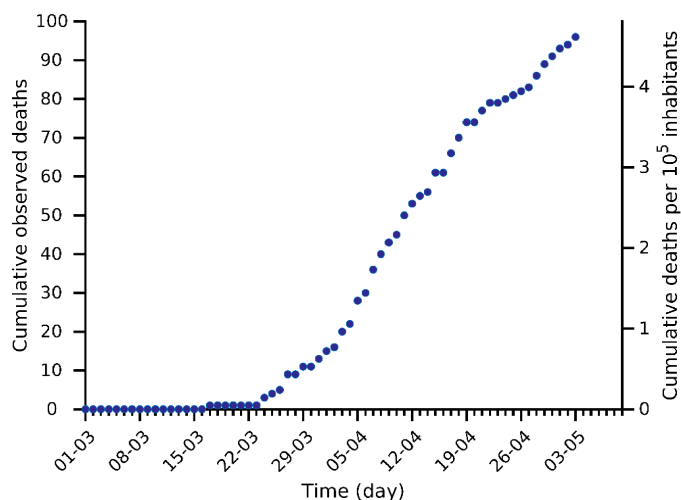
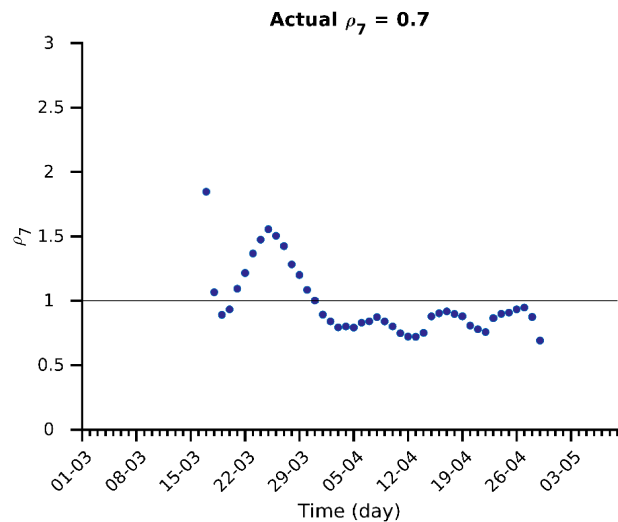
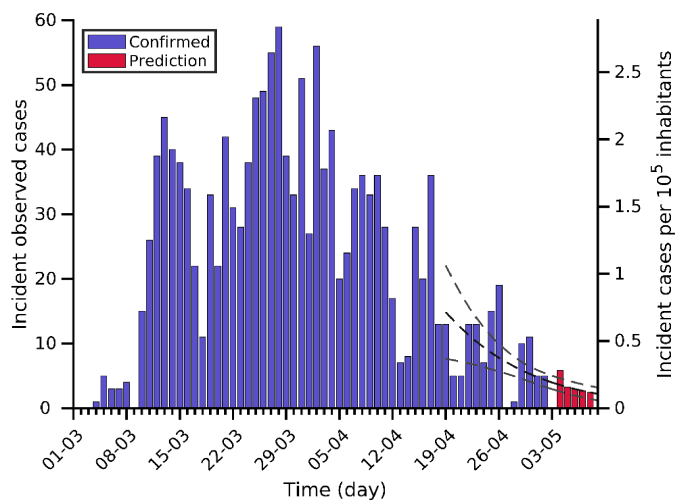
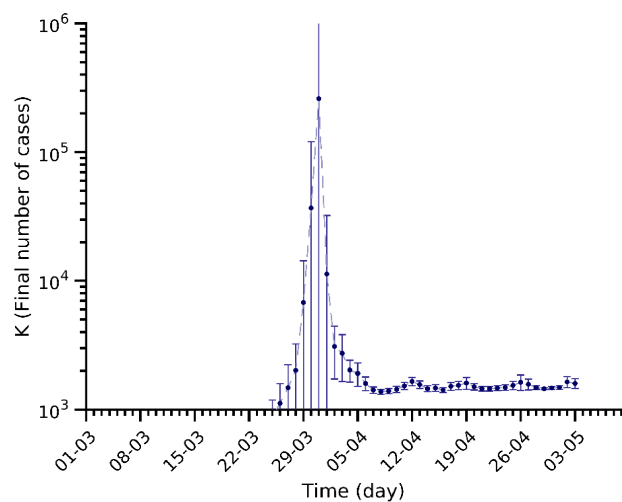
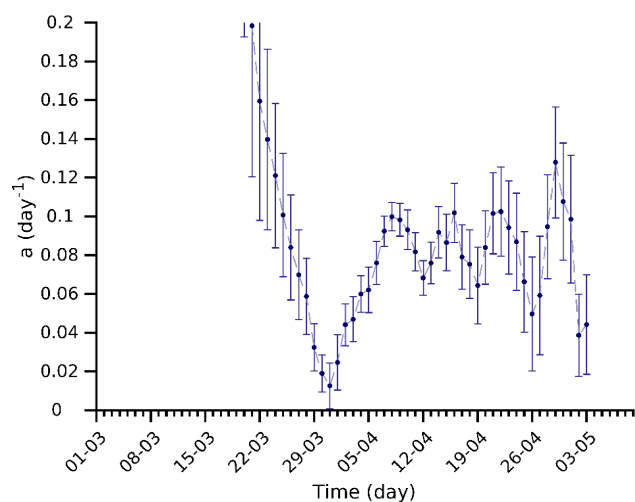
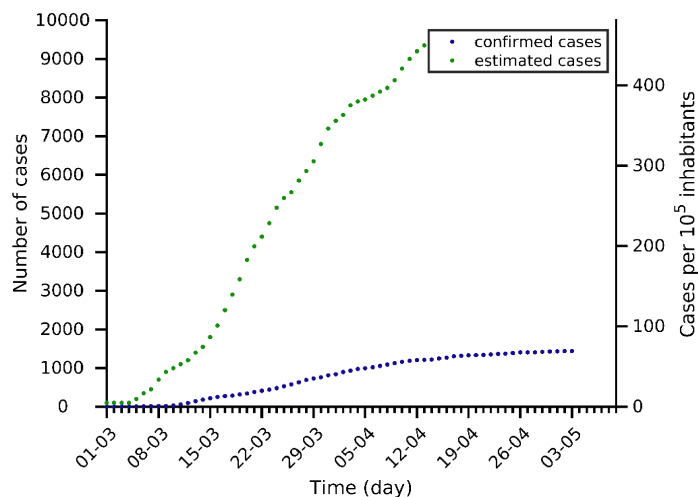
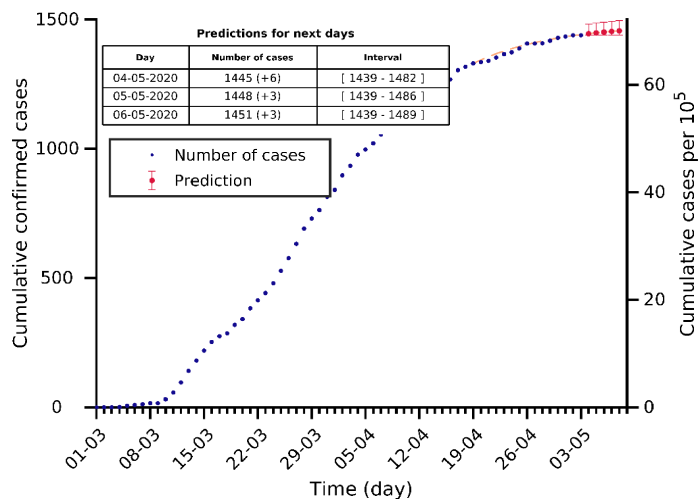
Estonia 03-05-2020. Population: 1.3M. Current cumulated incidence: 128/10⁵



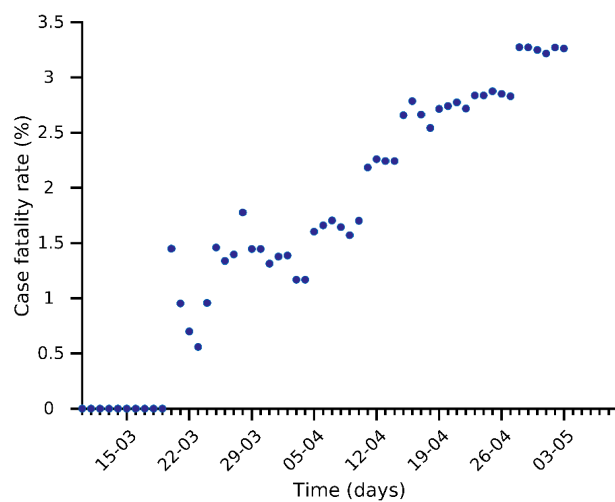
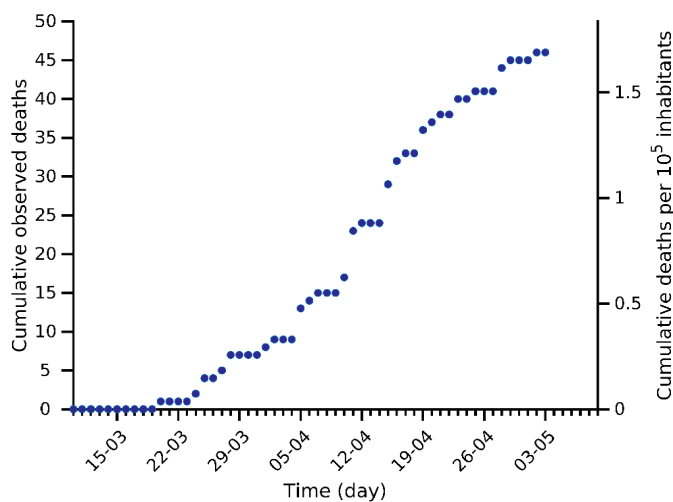
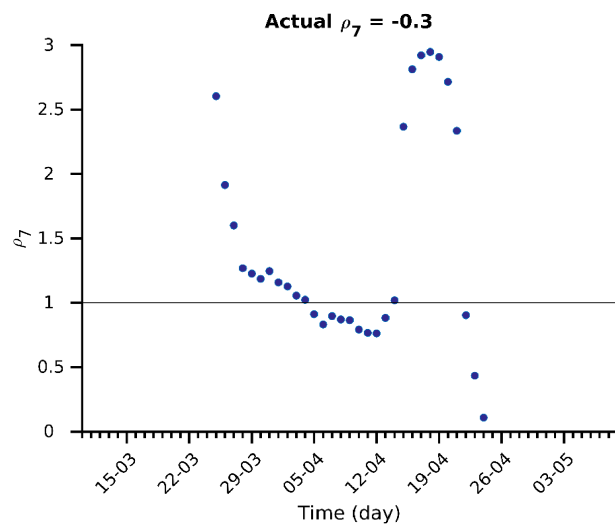
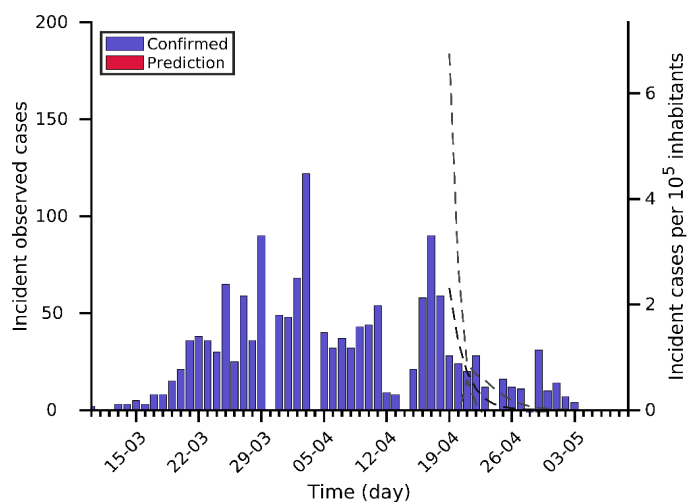
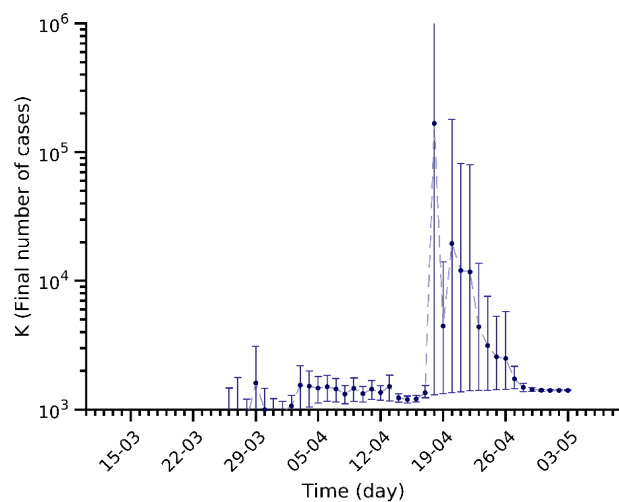
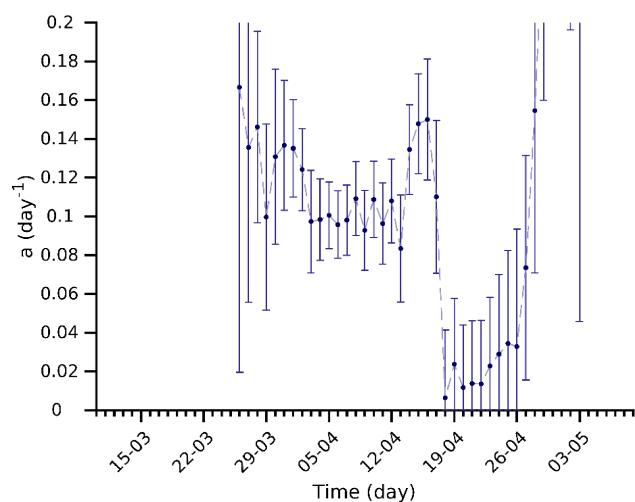
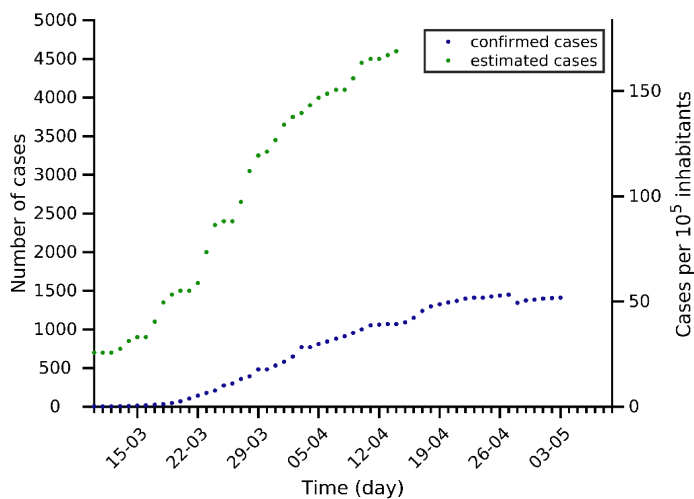
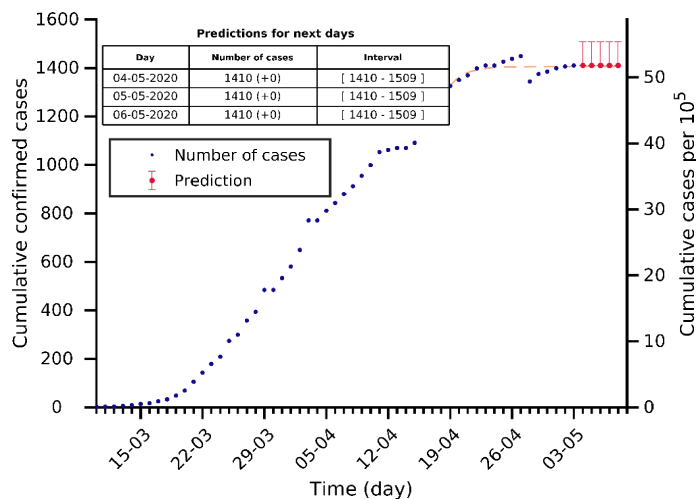
Bulgaria 03-05-2020. Population: 6.9M. Current cumulated incidence: 23/10⁵



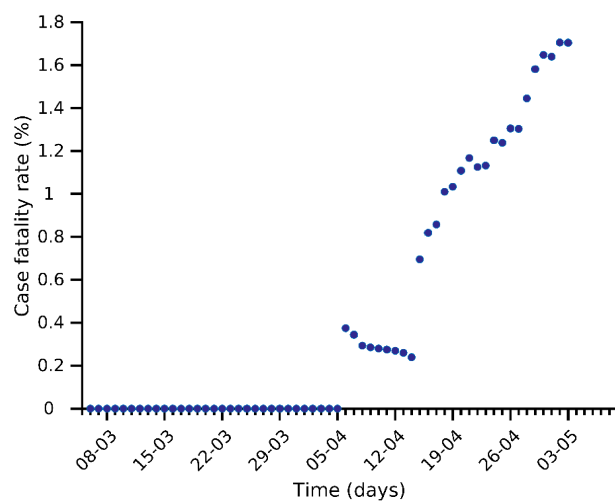
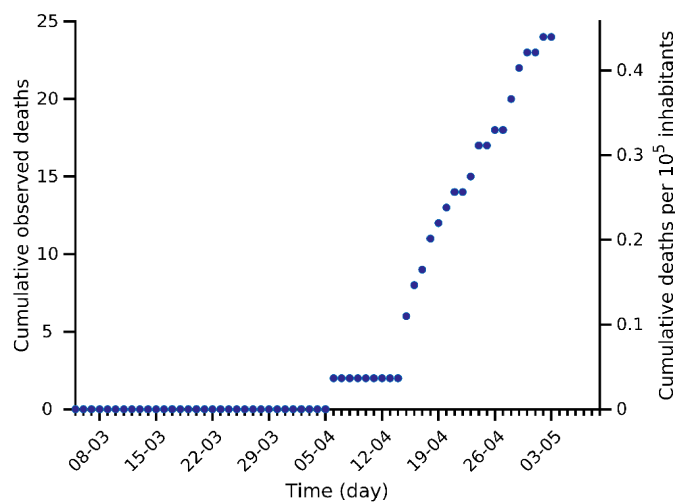
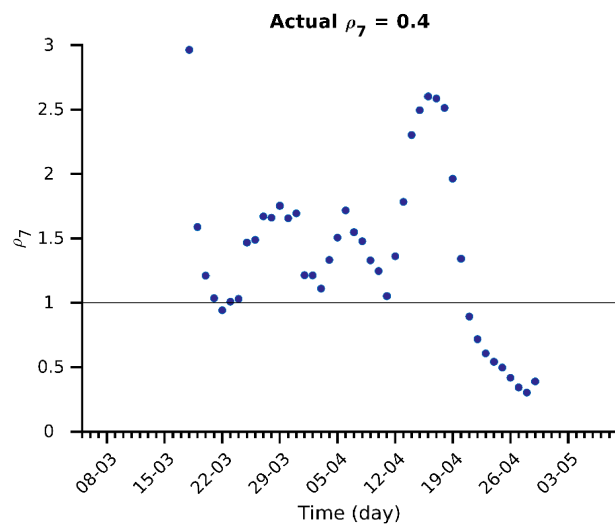
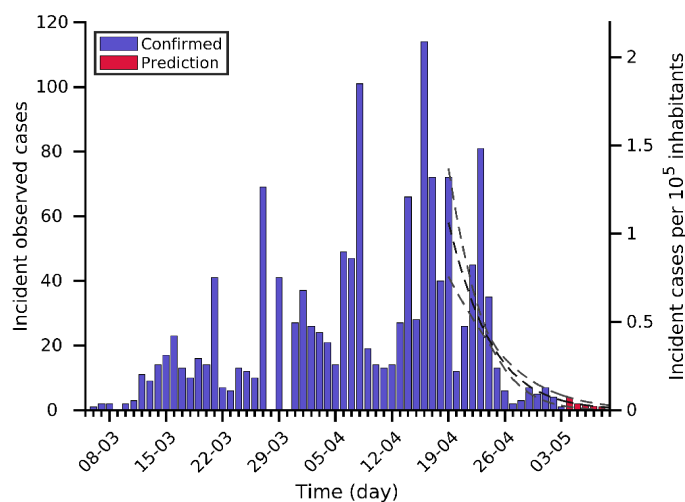
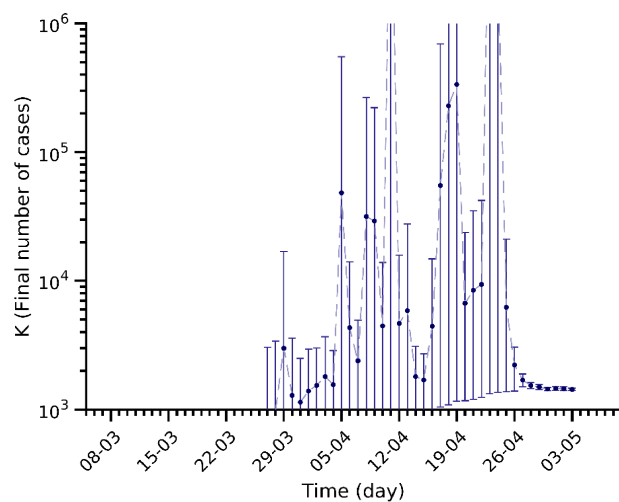
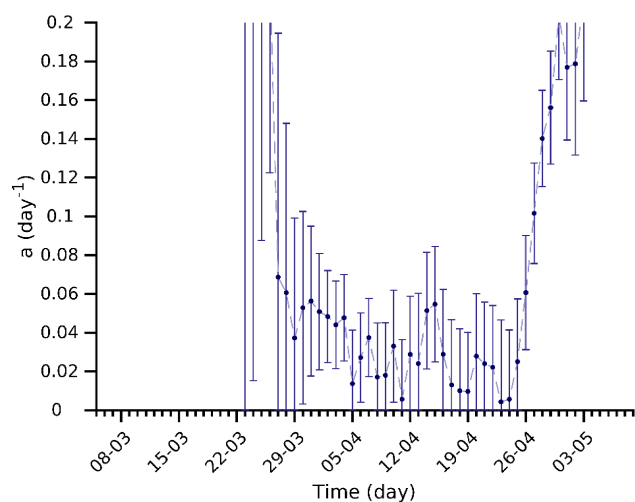
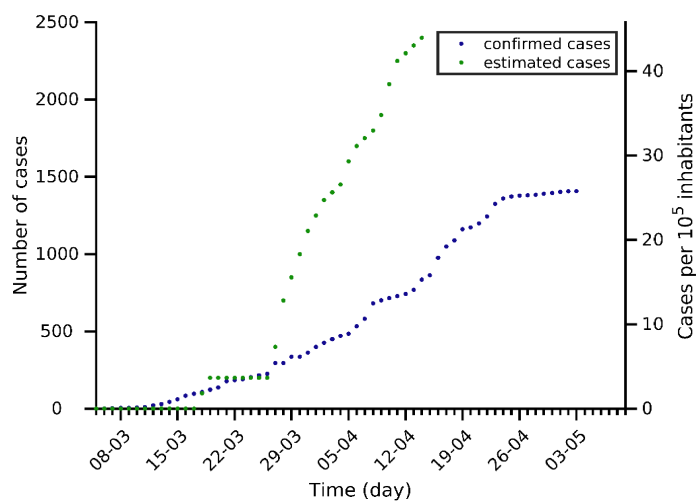
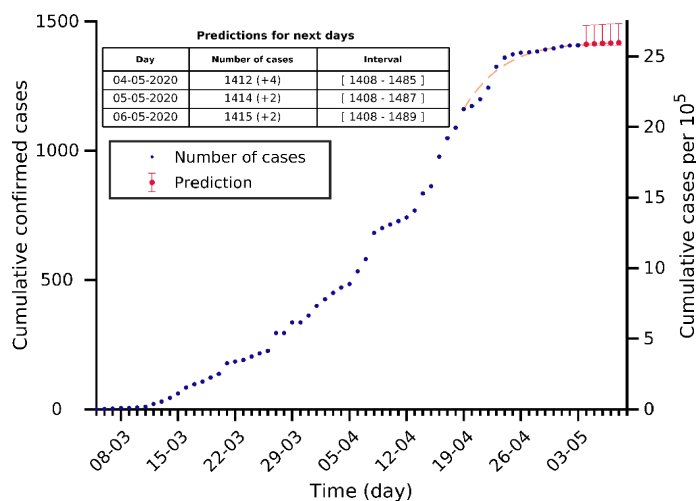
Slovenia 03-05-2020. Population: 2.1M. Current cumulated incidence: 69/10⁵



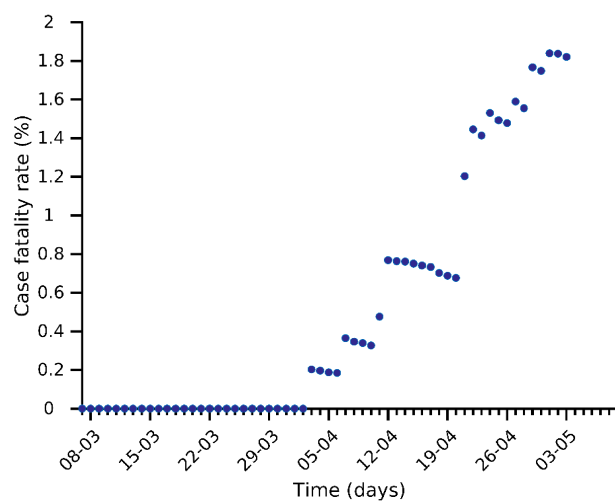
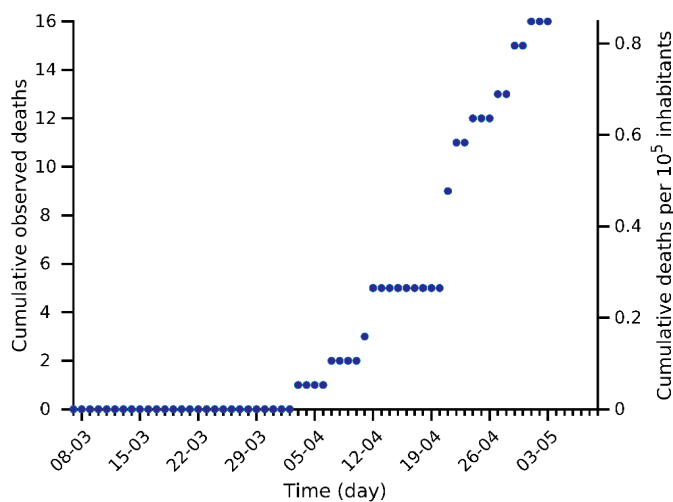
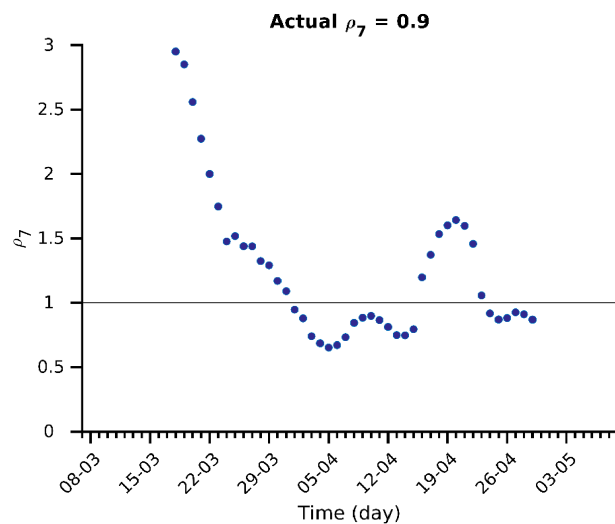
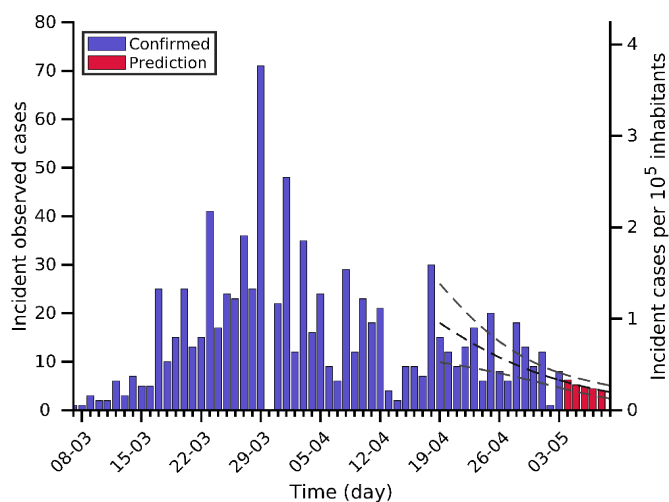
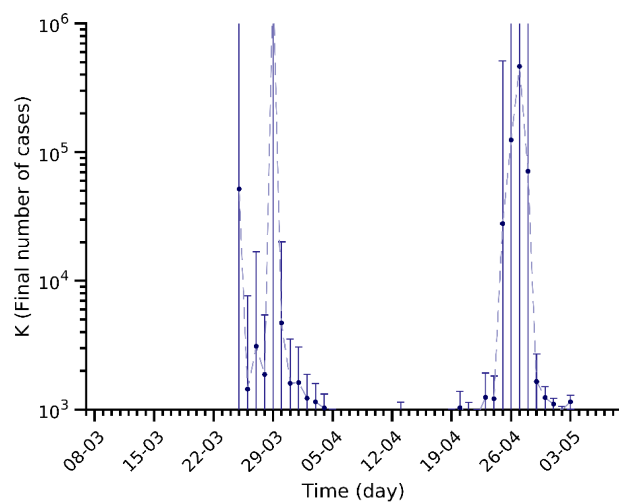
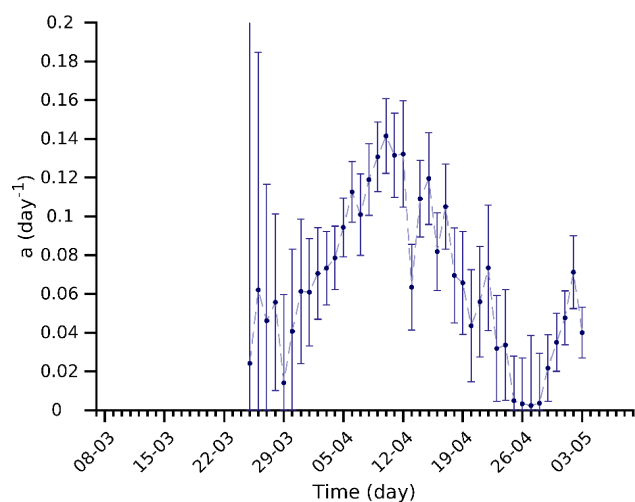
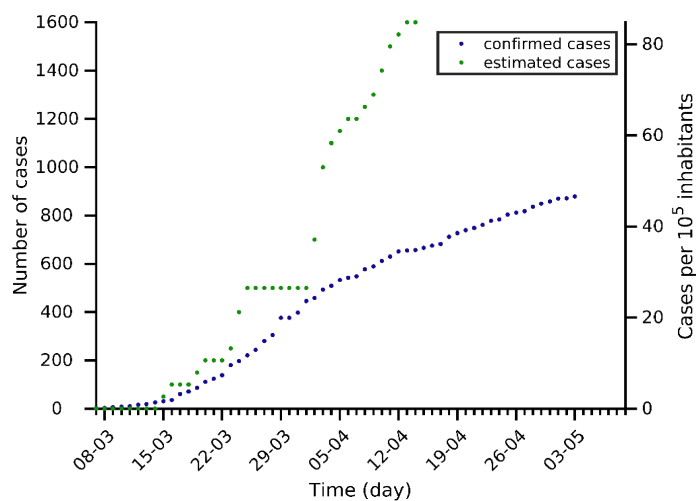
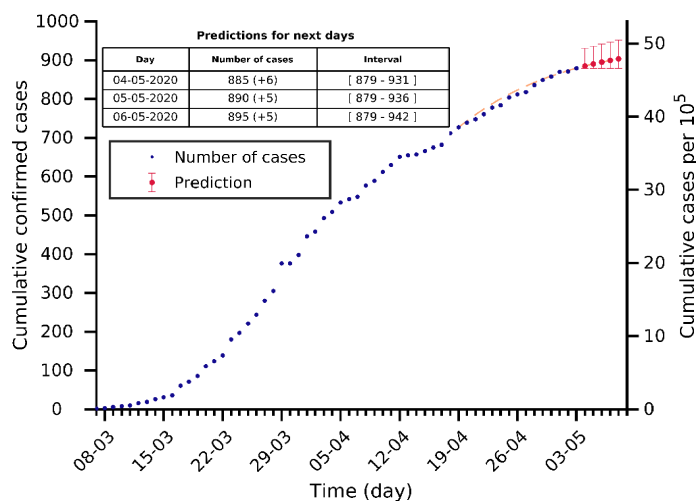
Lithuania 03-05-2020. Population: 2.7M. Current cumulated incidence: 52/10⁵



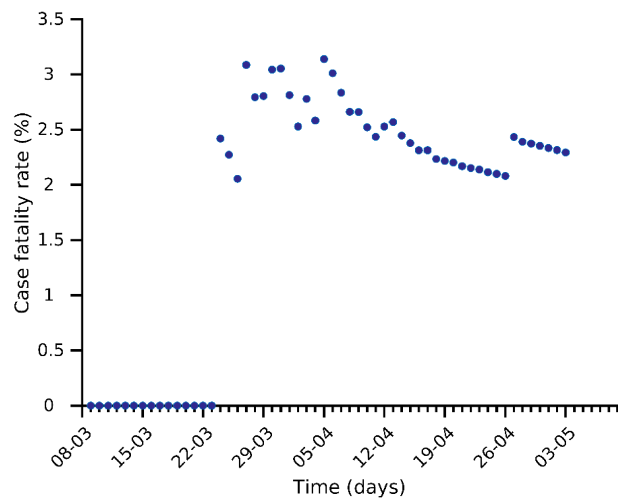
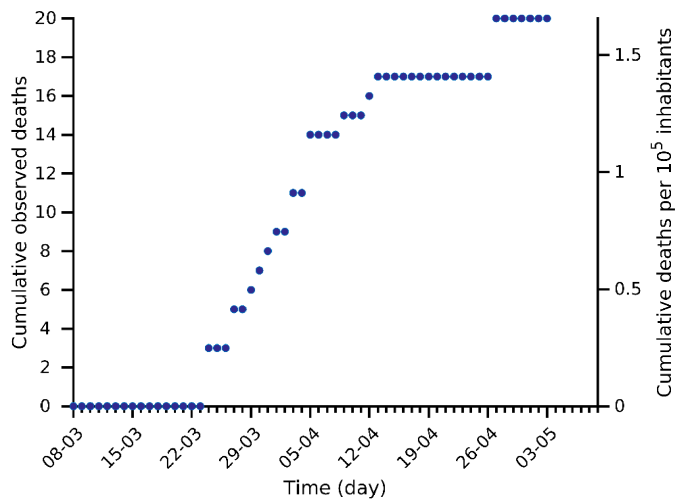
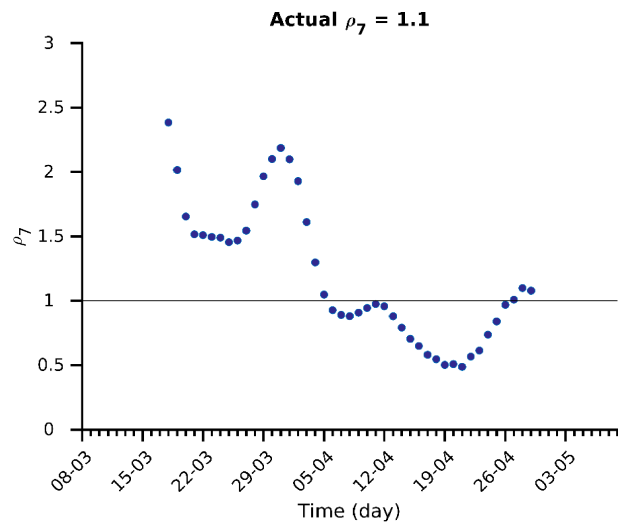
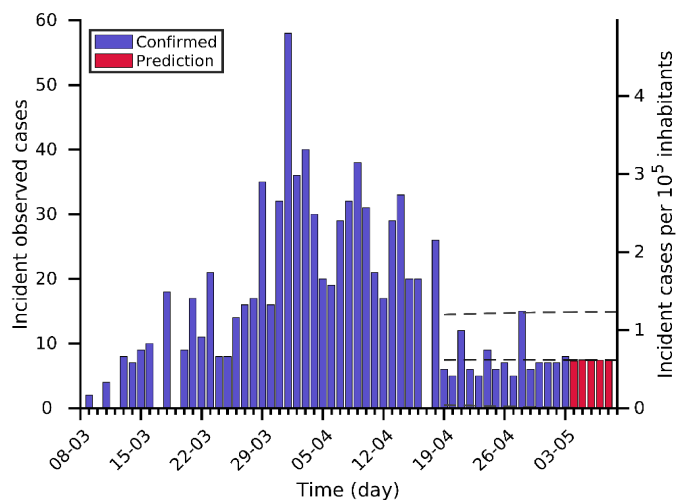
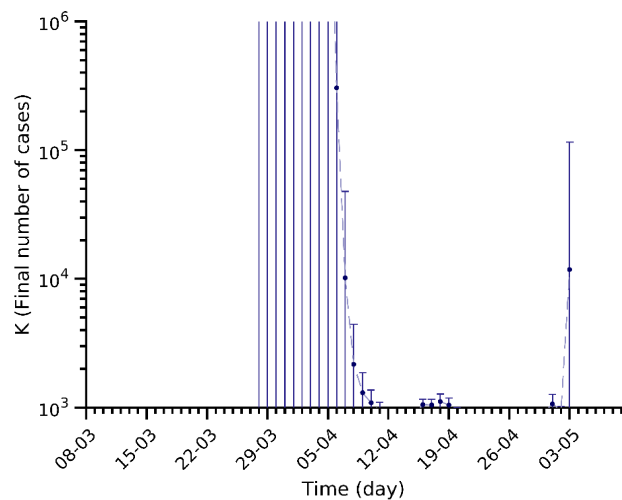
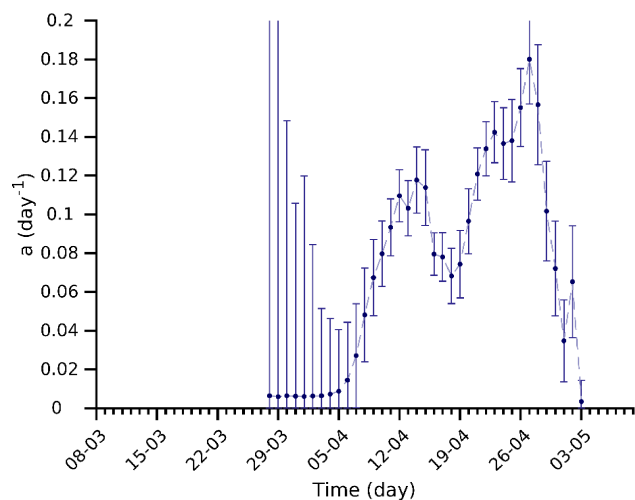
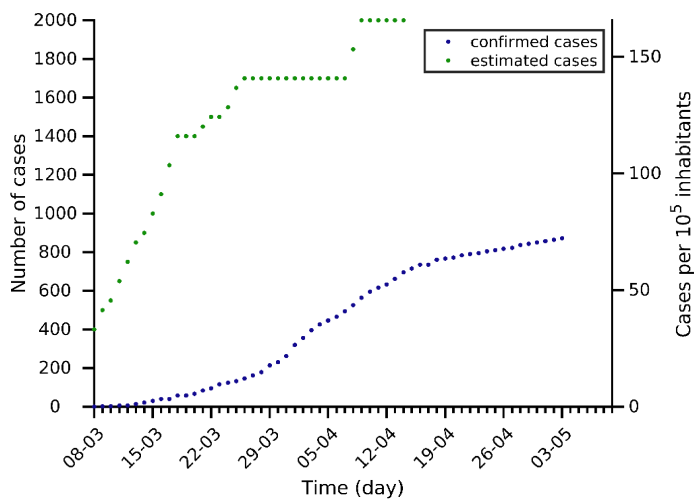
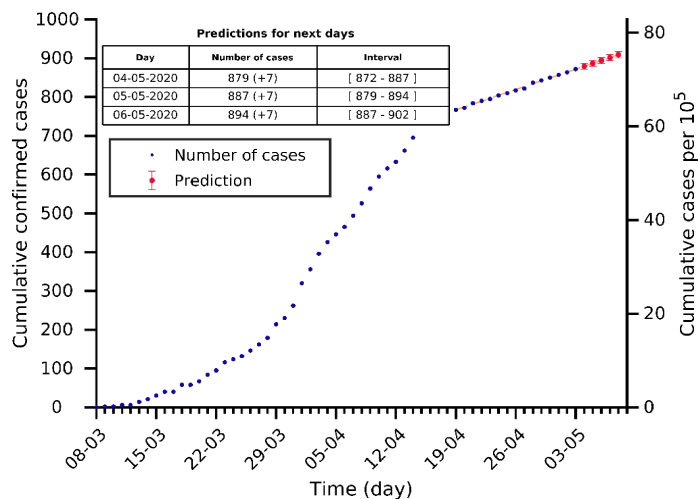
Slovakia 03-05-2020. Population: 5.5M. Current cumulated incidence: 26/10⁵



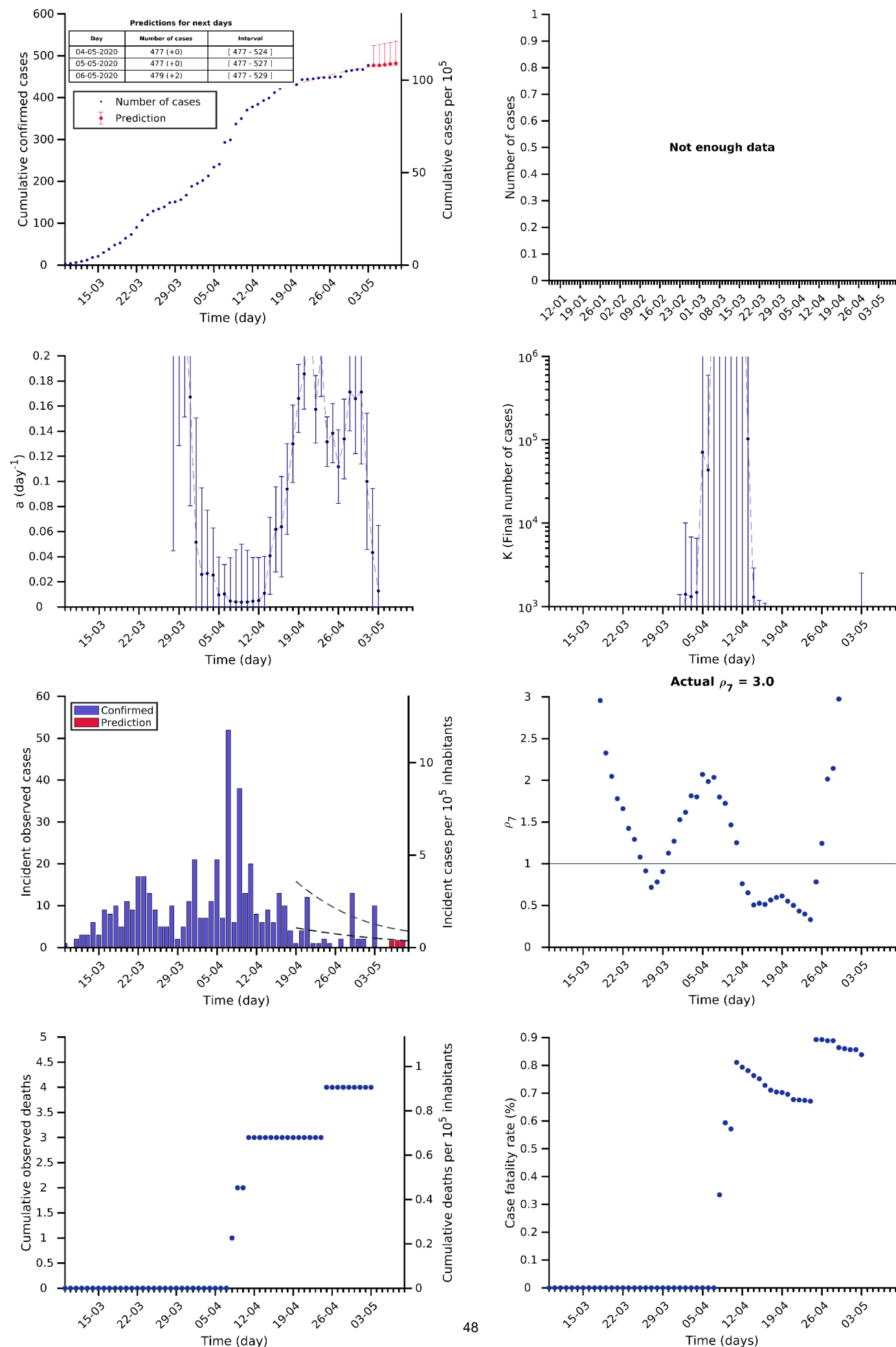
Latvia 03-05-2020. Population: 1.9M. Current cumulated incidence: 47/10⁵



Cyprus 03-05-2020. Population: 1.2M. Current cumulated incidence: 72/10⁵



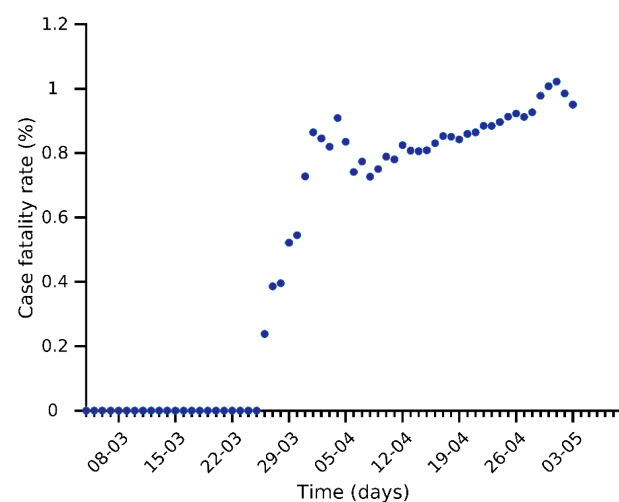
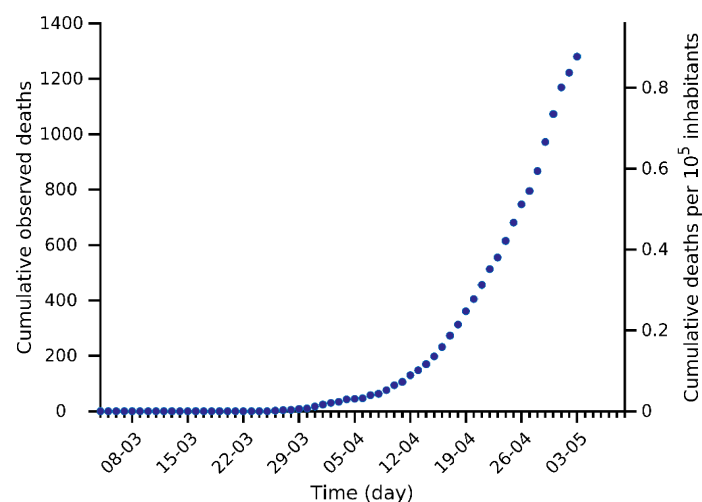
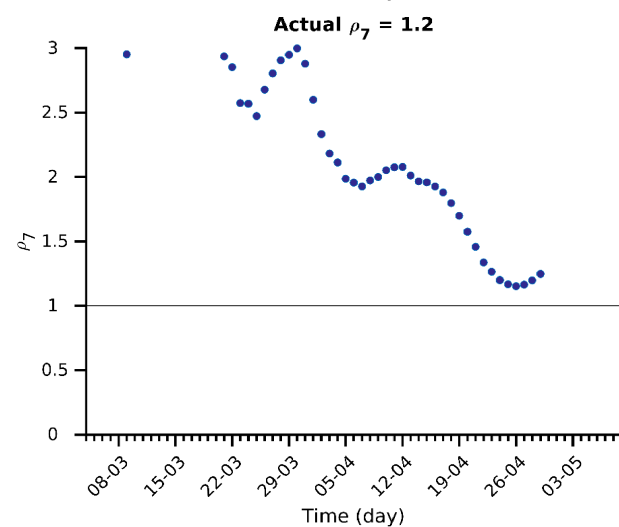
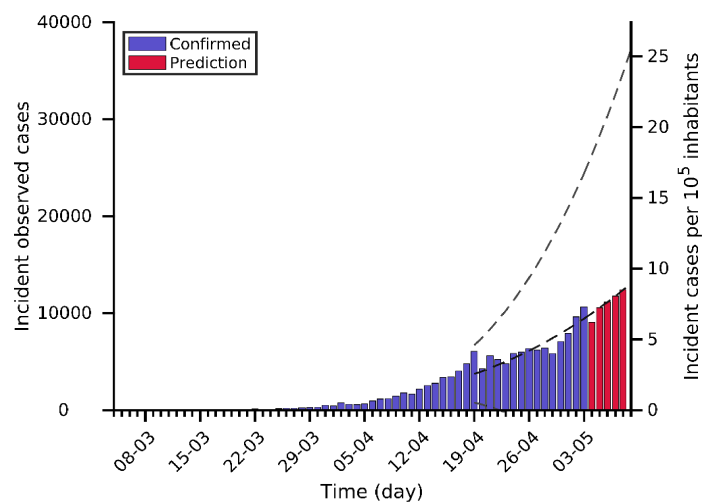
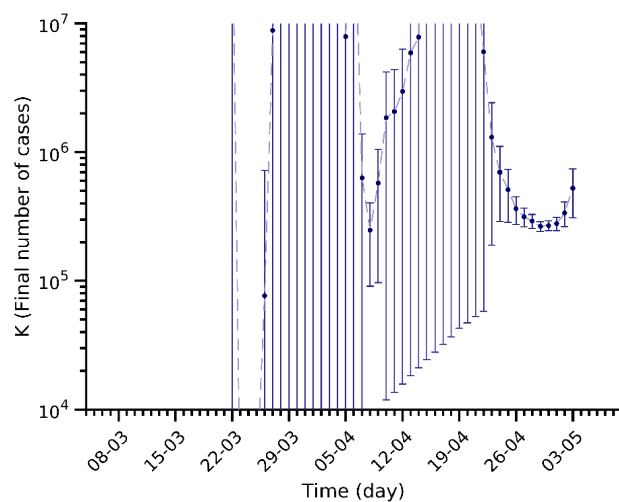
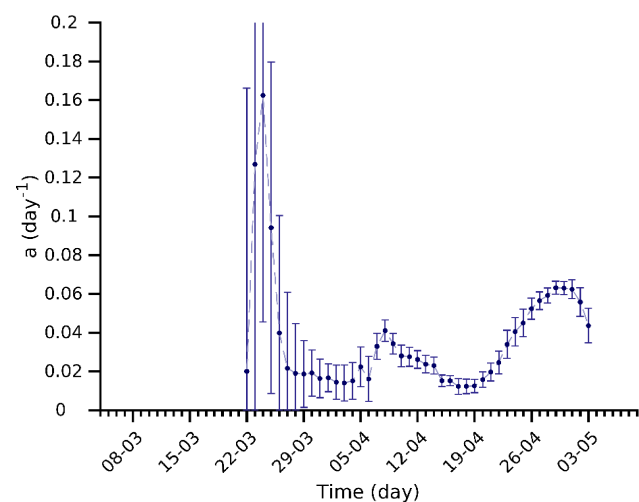
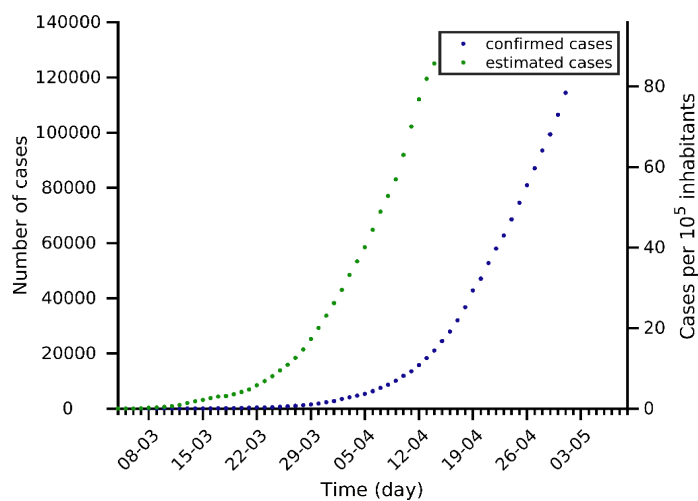
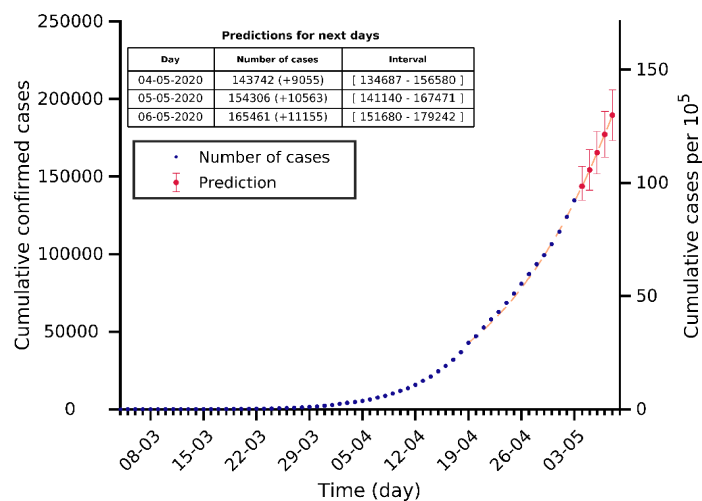
Malta 03-05-2020. Population: 0.4M. Current cumulated incidence: 108/10⁵



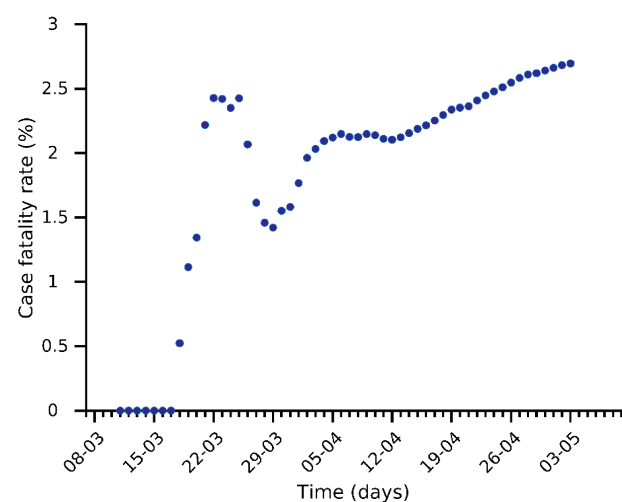
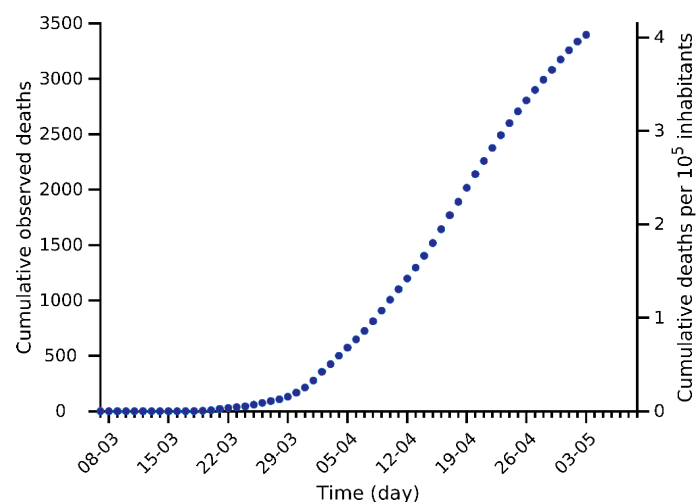
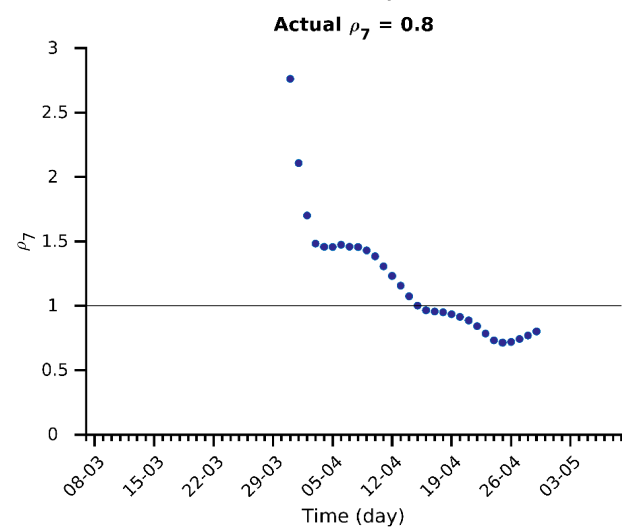
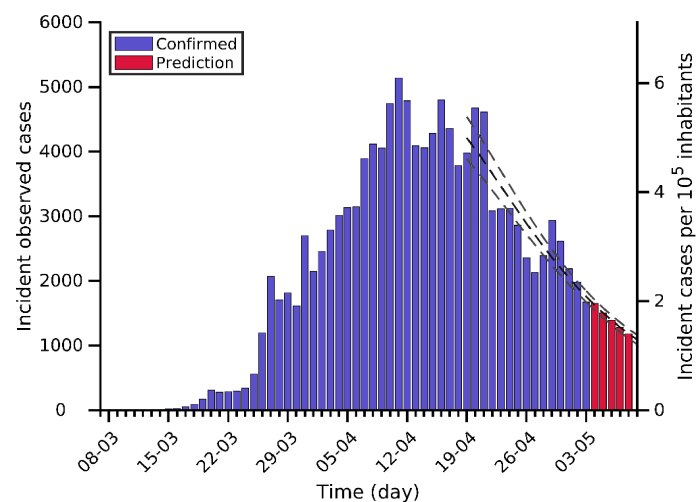
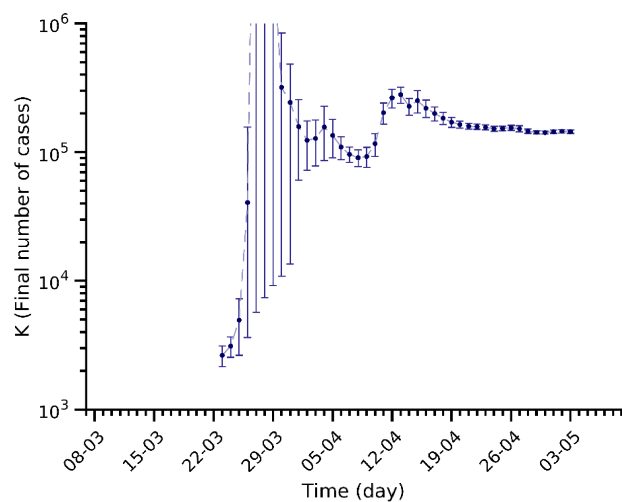
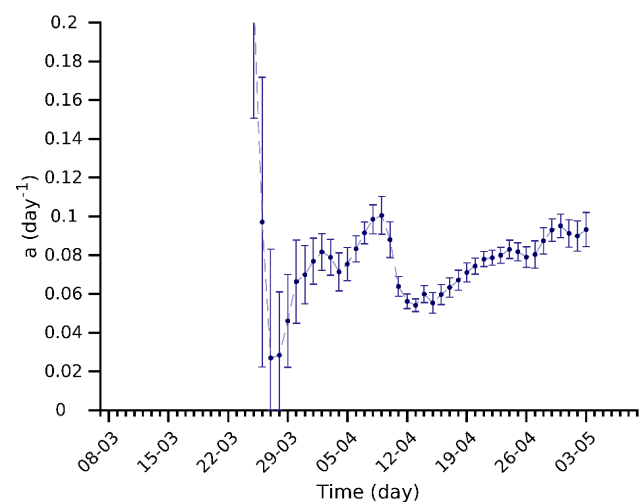
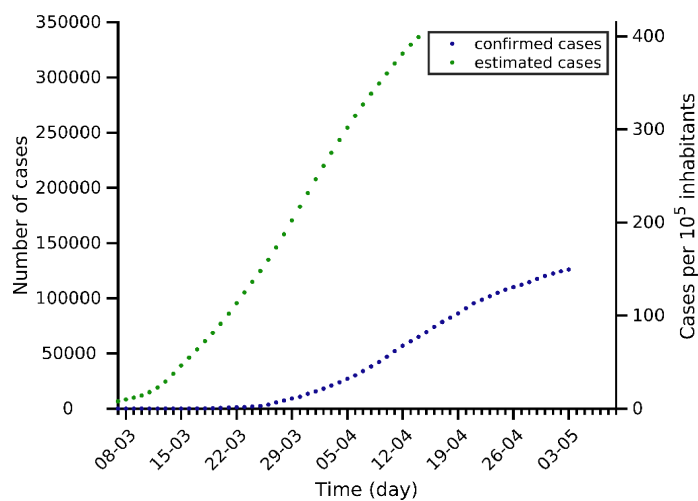
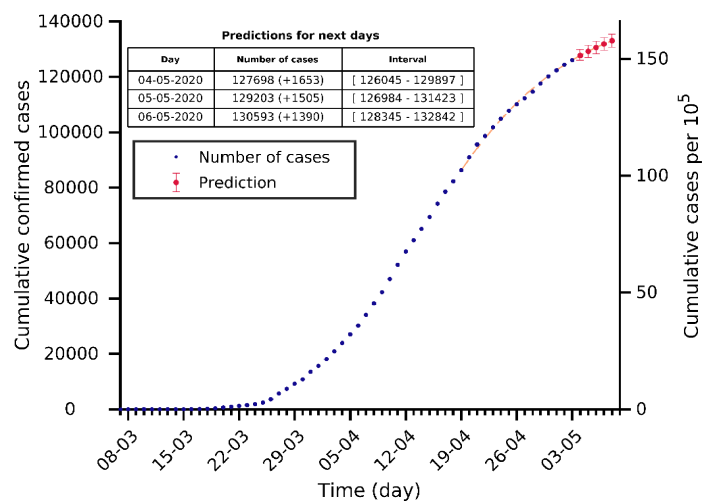
(2) Analysis and prediction of COVID-19 for other countries

Data obtained from <https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases>

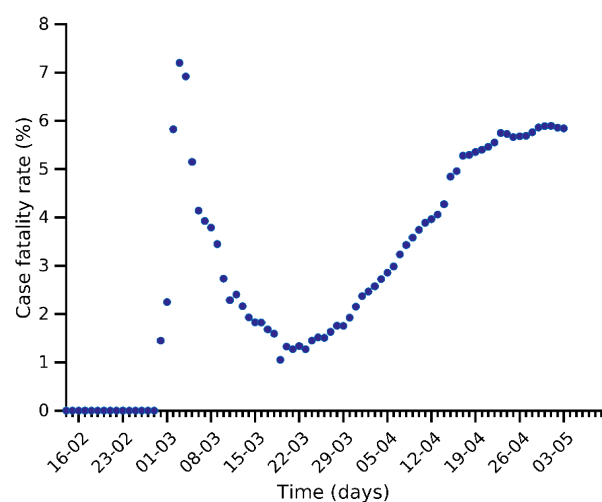
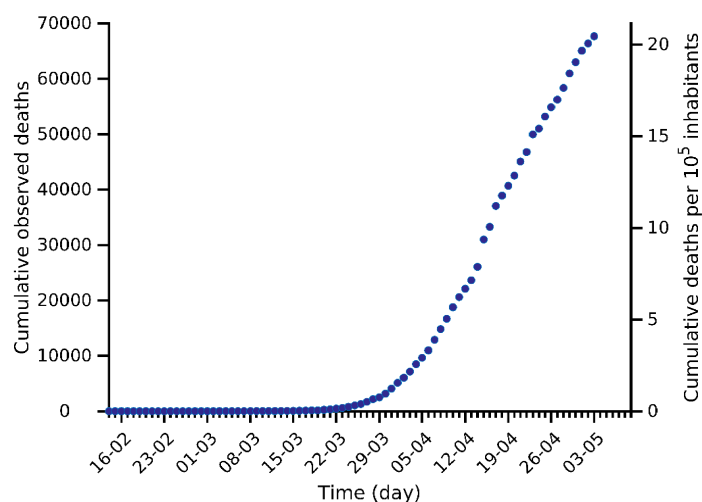
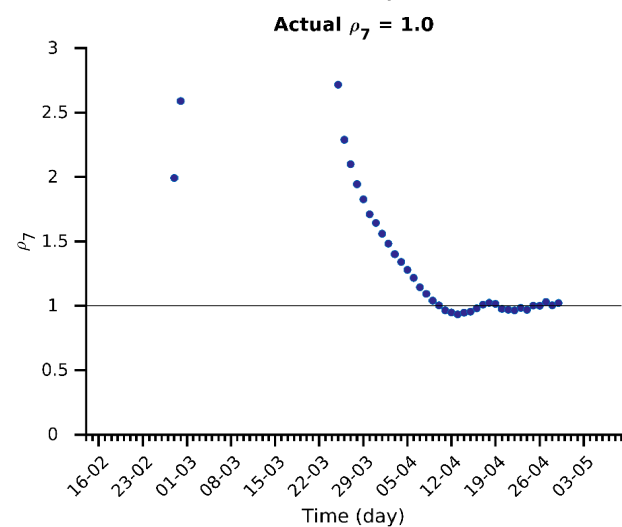
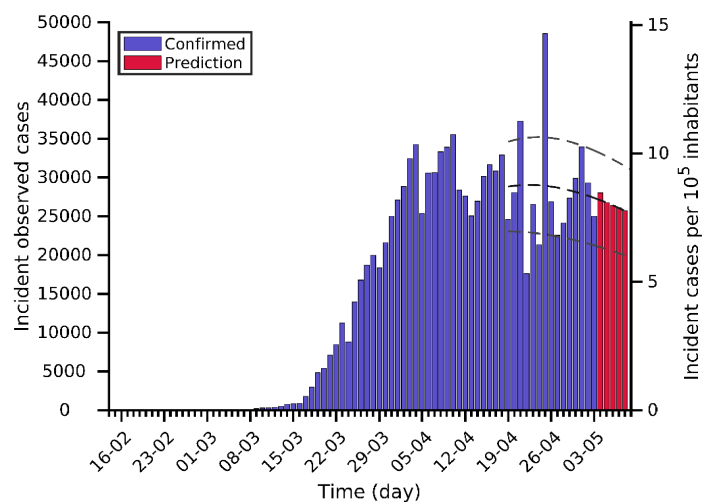
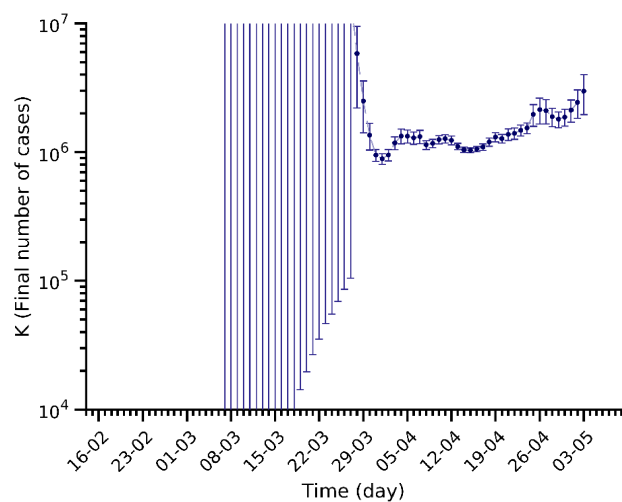
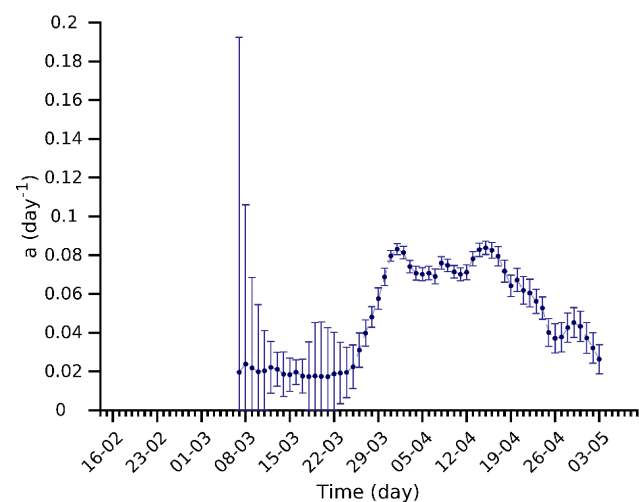
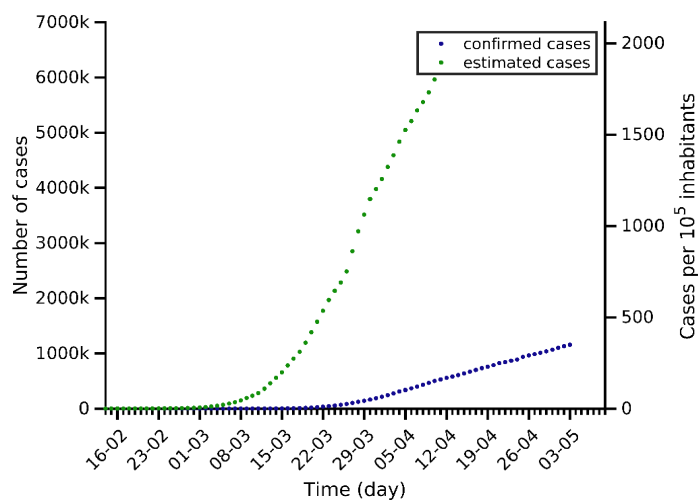
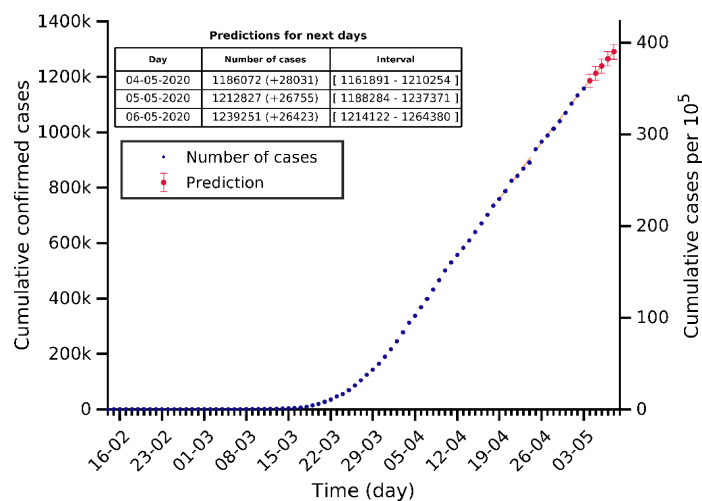
Russia 03-05-2020. Population: 145.9M. Current cumulated incidence: 92/10⁵



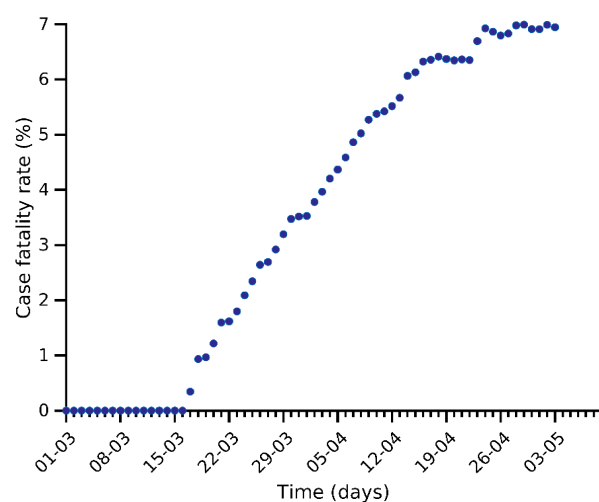
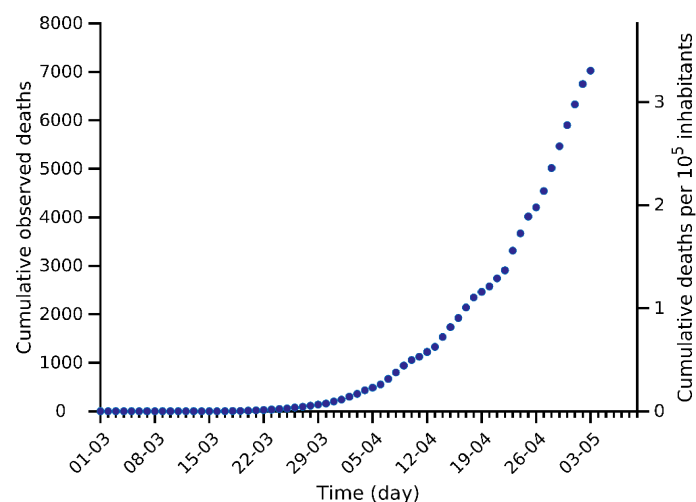
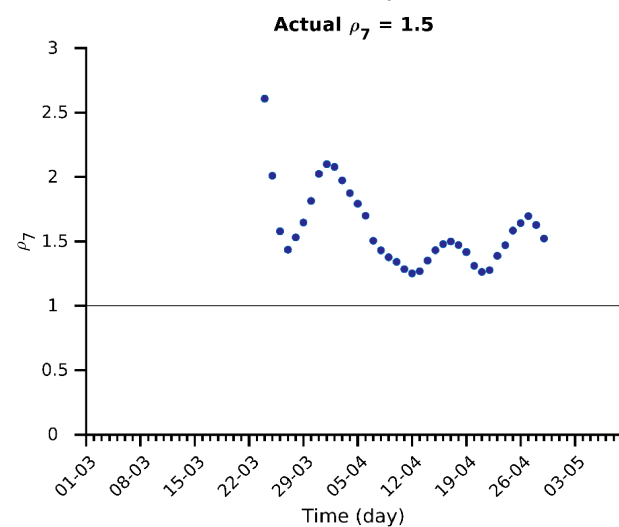
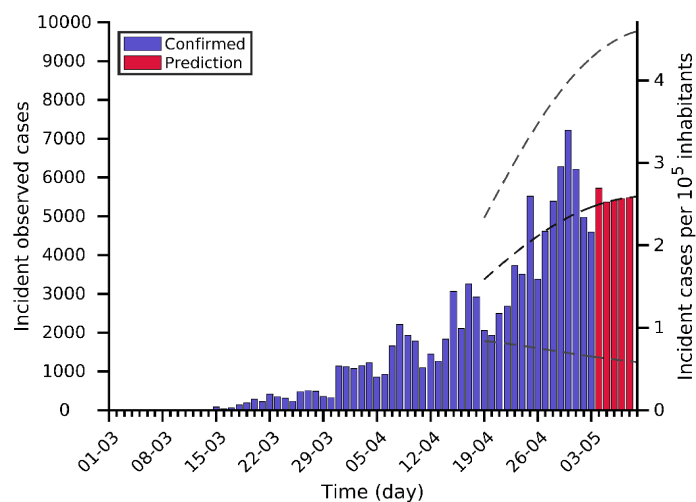
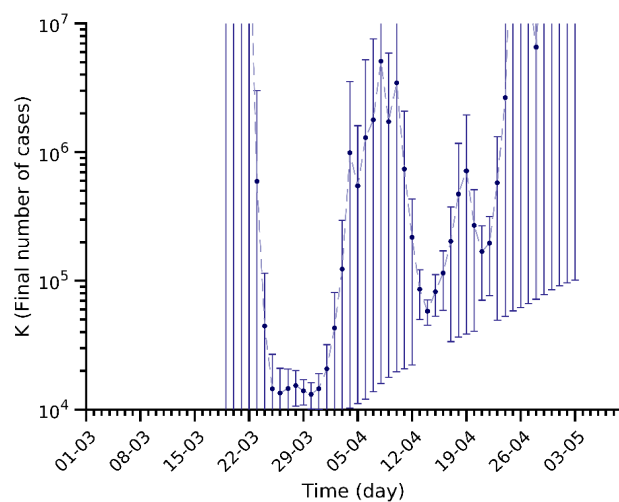
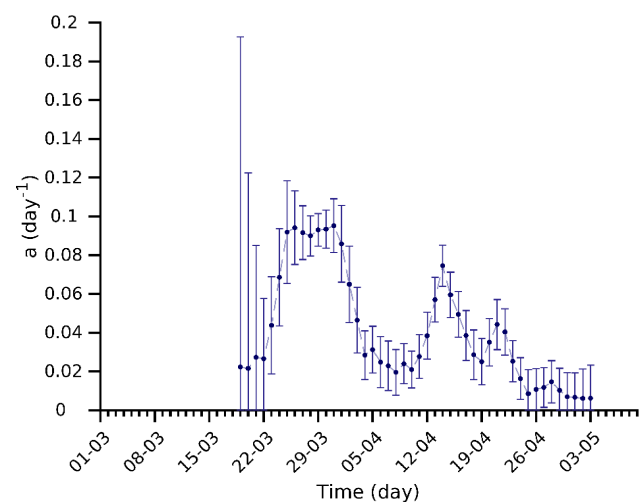
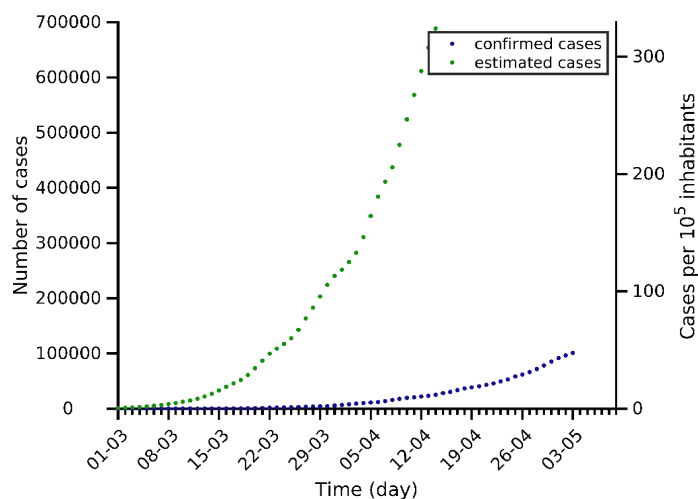
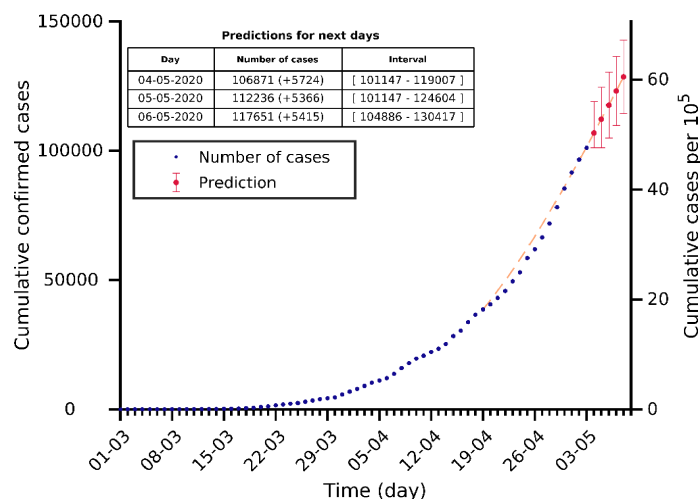
Turkey 03-05-2020. Population: 84.3M. Current cumulated incidence: 149/10⁵



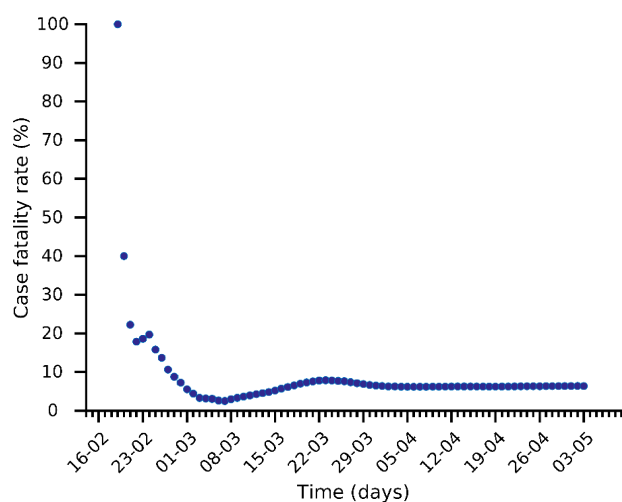
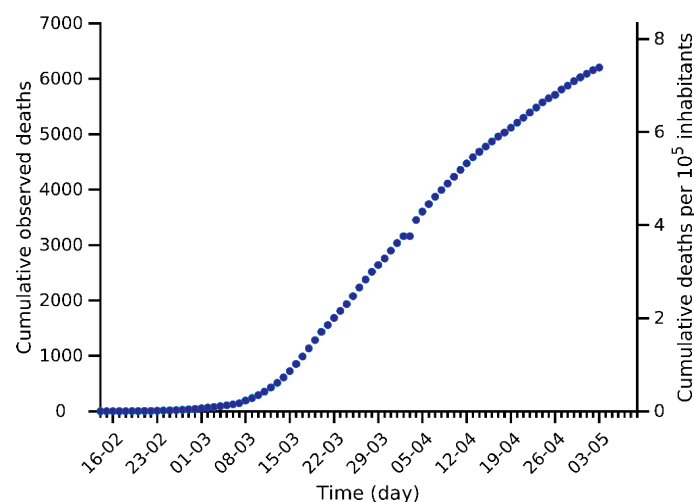
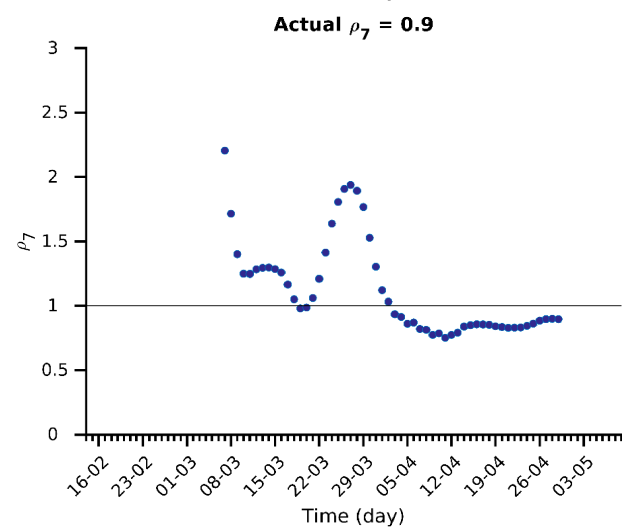
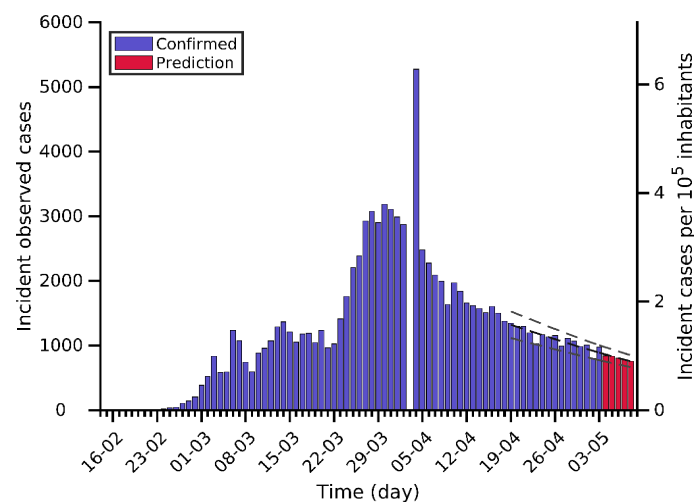
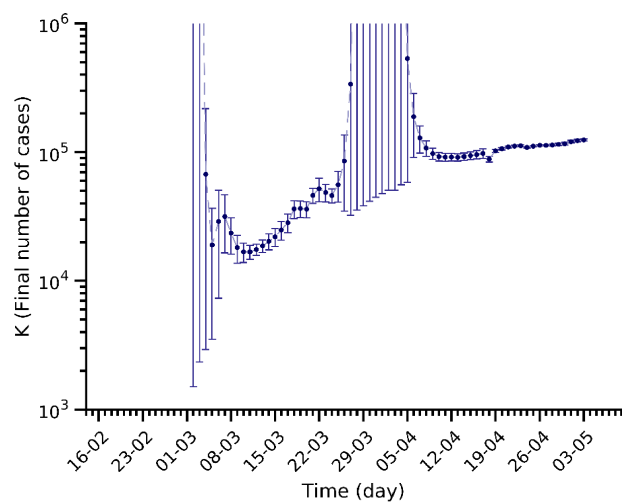
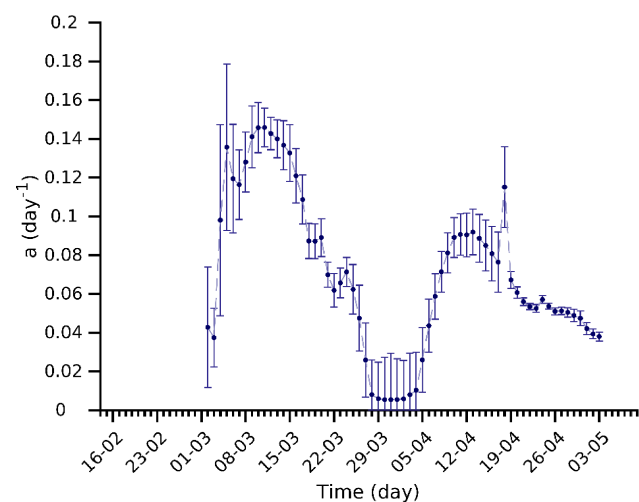
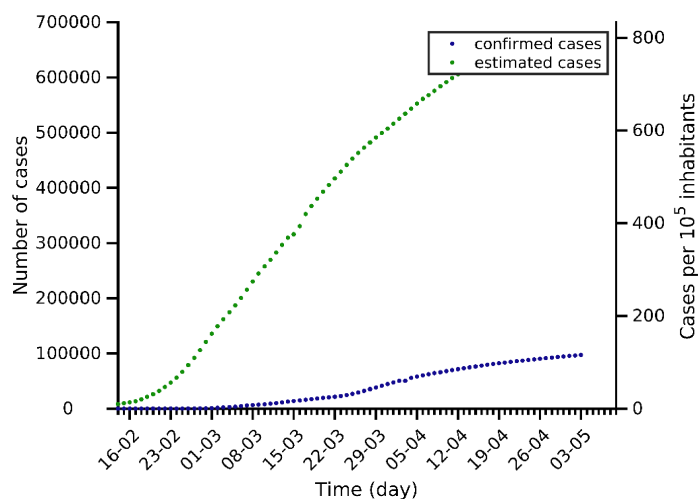
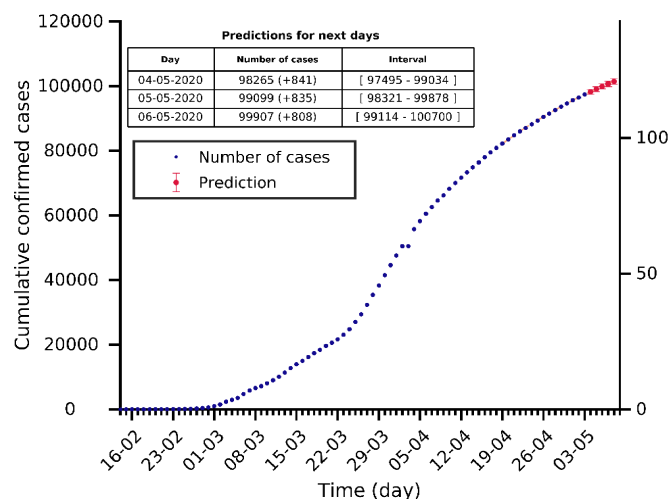
USA 03-05-2020. Population: 331.0M. Current cumulated incidence: 350/10⁵



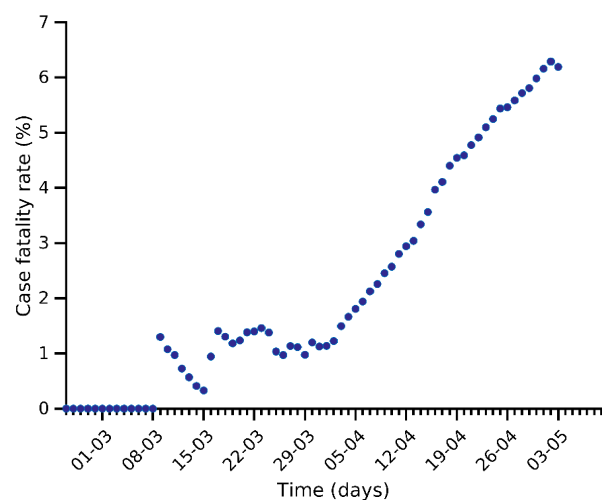
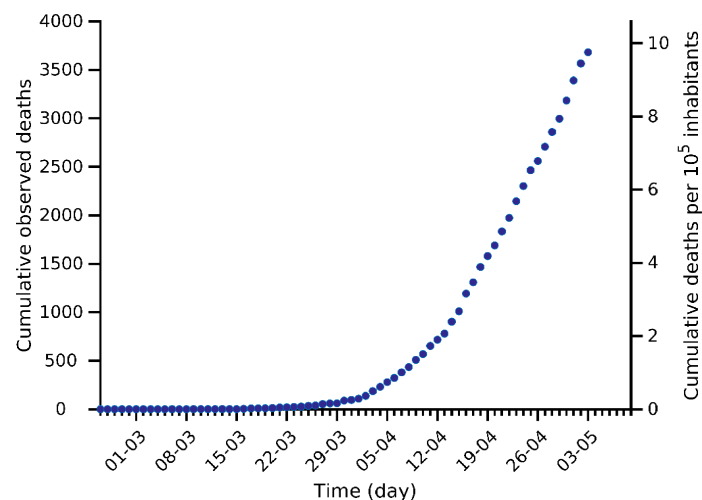
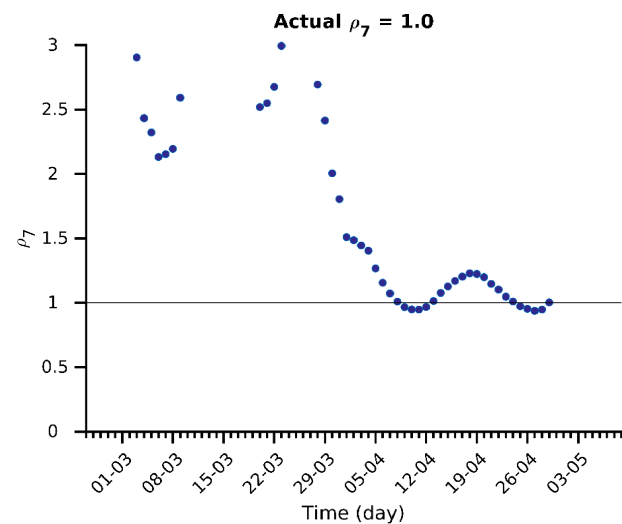
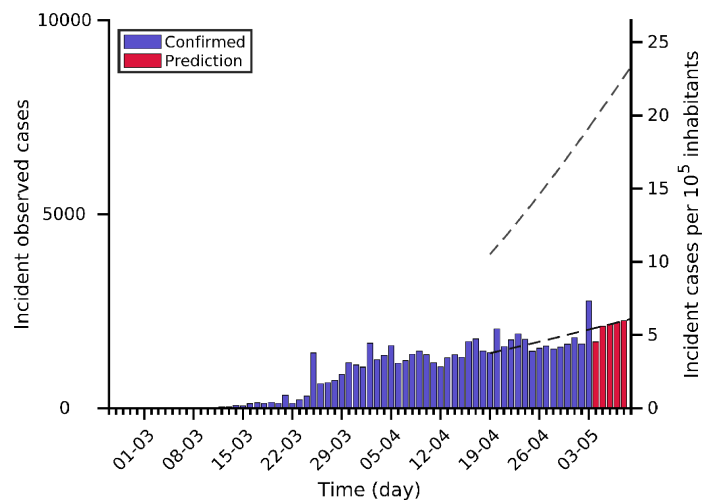
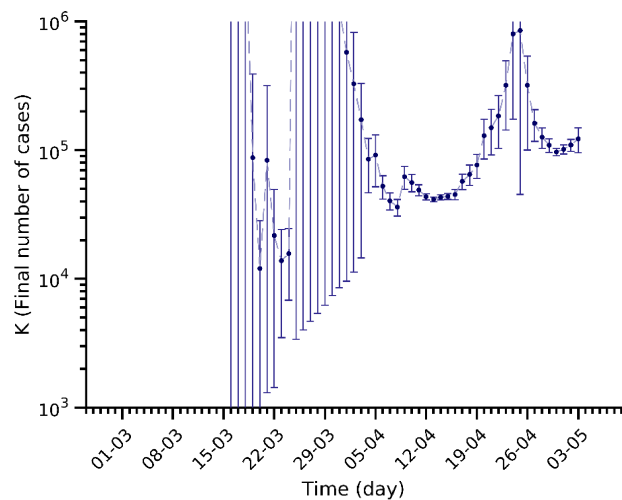
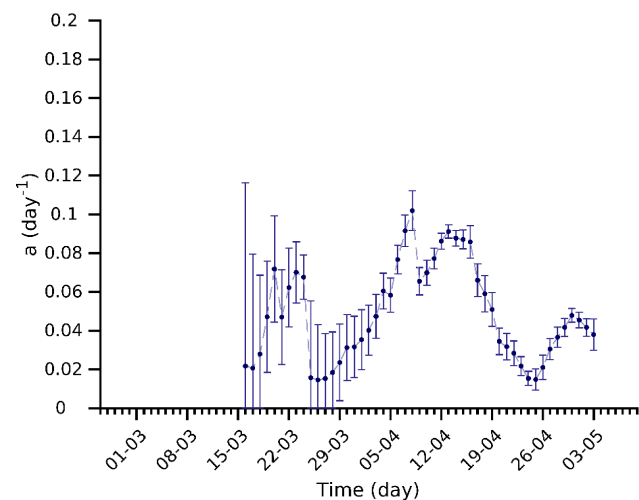
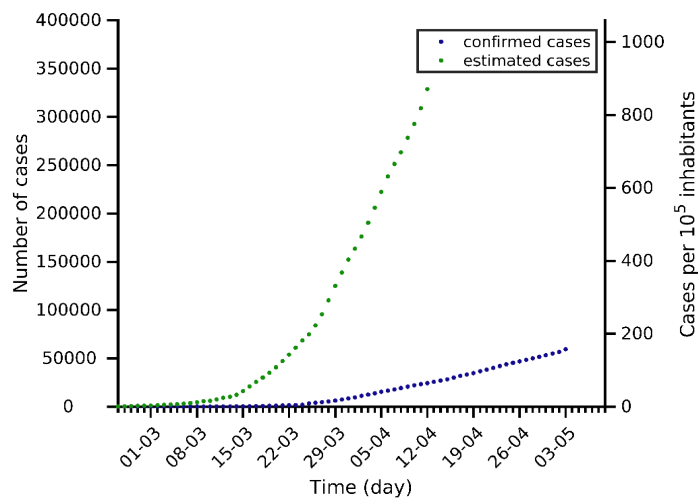
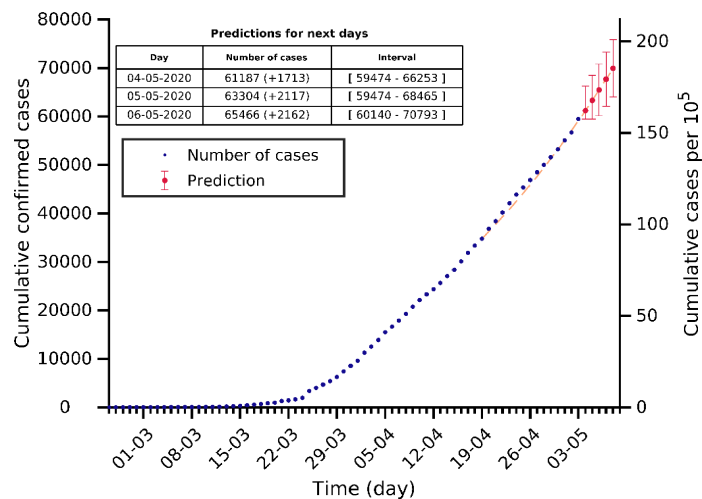
Brazil 03-05-2020. Population: 212.6M. Current cumulated incidence: 48/10⁵



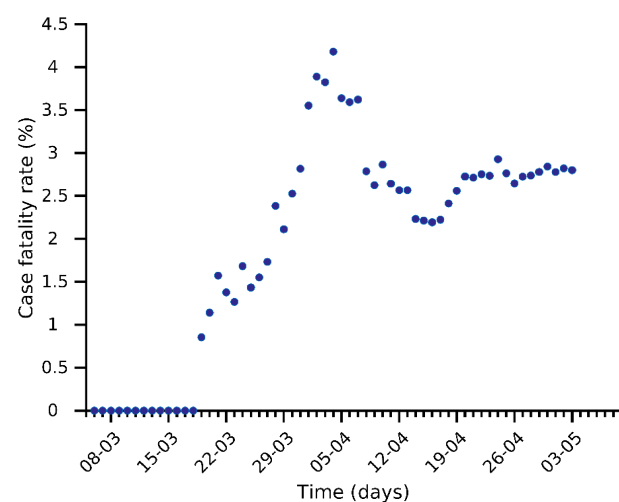
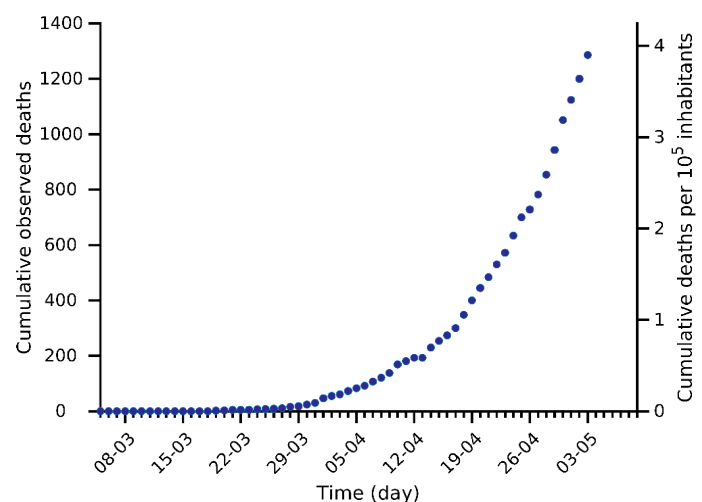
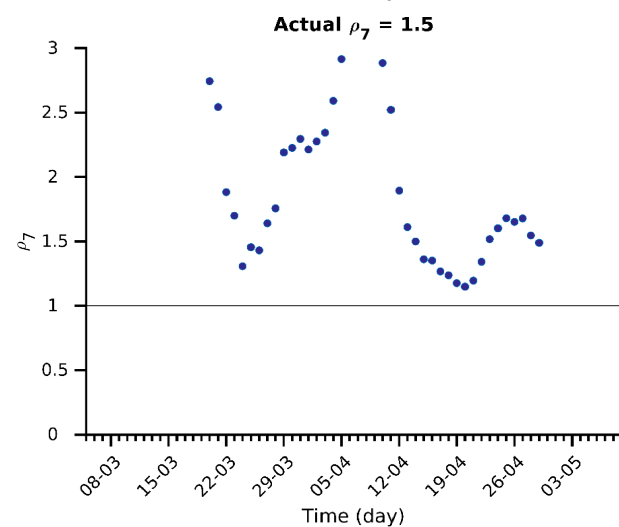
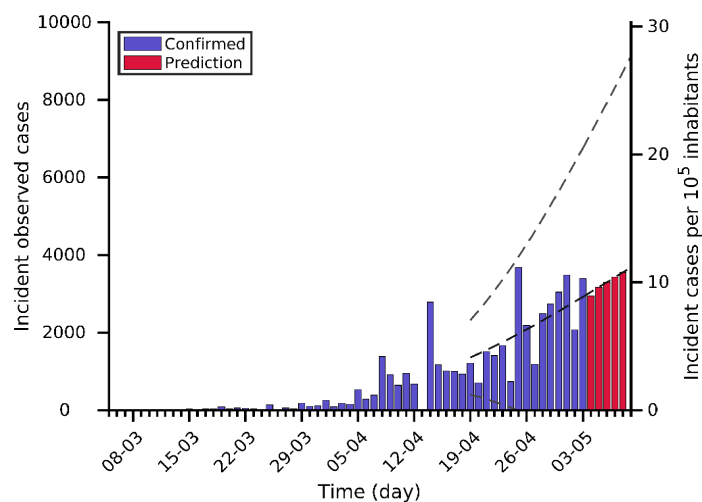
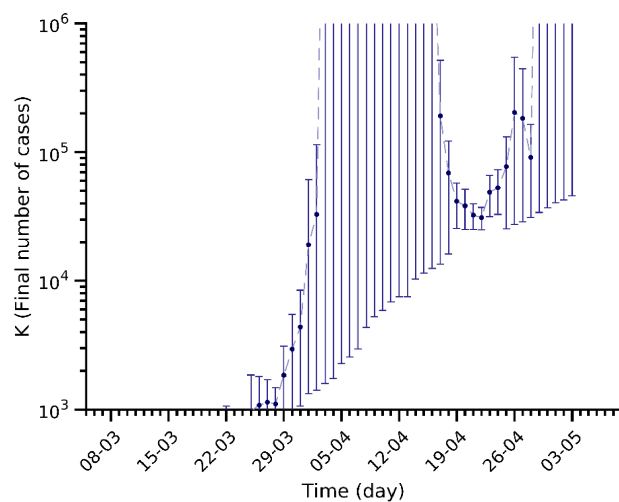
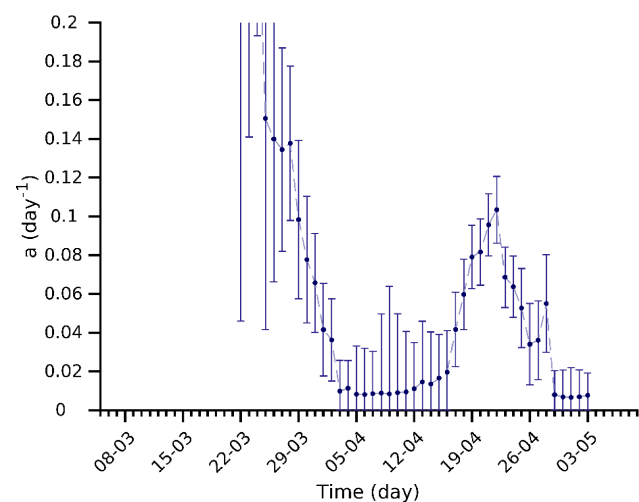
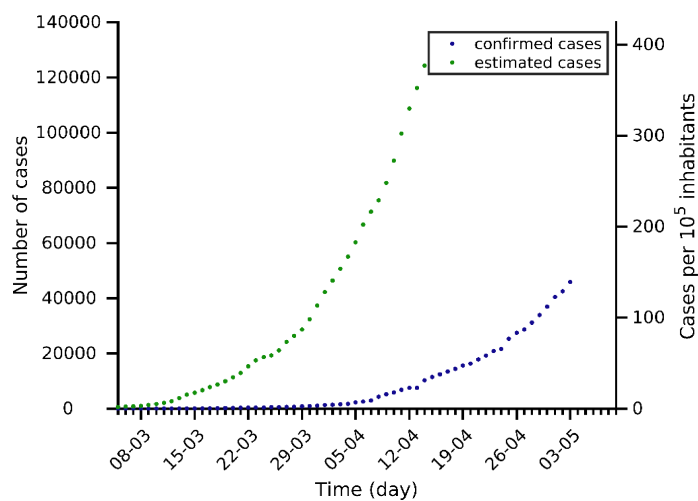
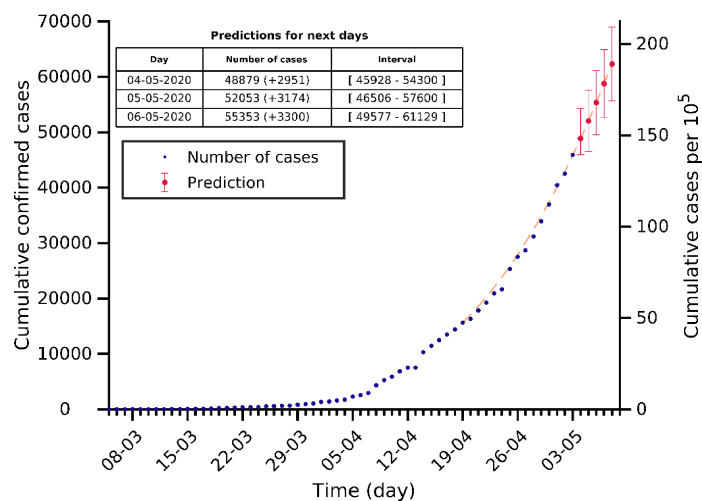
Iran 03-05-2020. Population: 84.0M. Current cumulated incidence: 116/10⁵



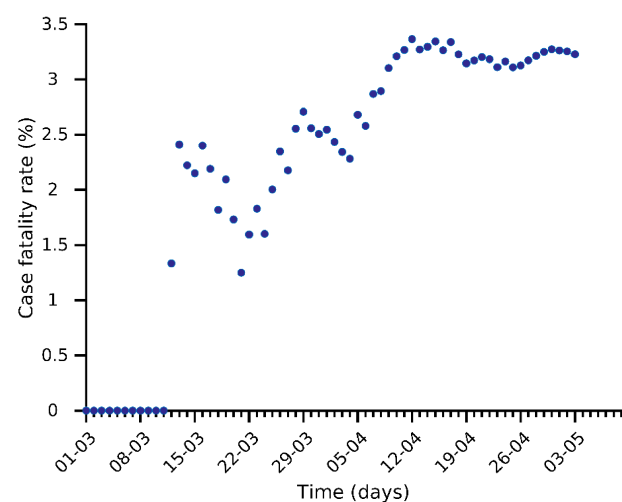
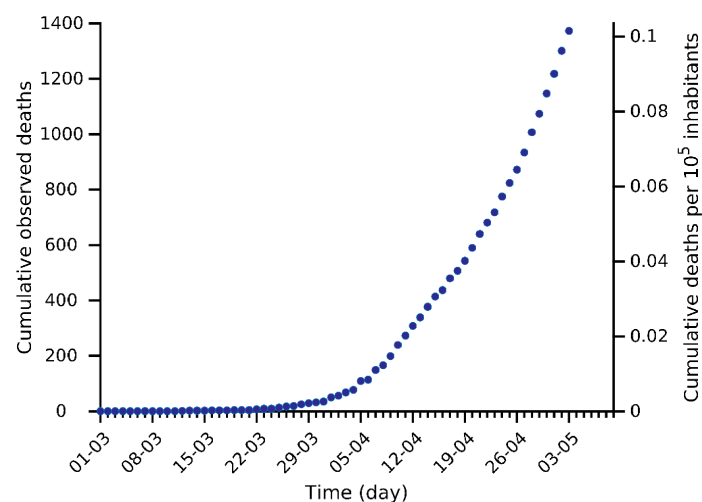
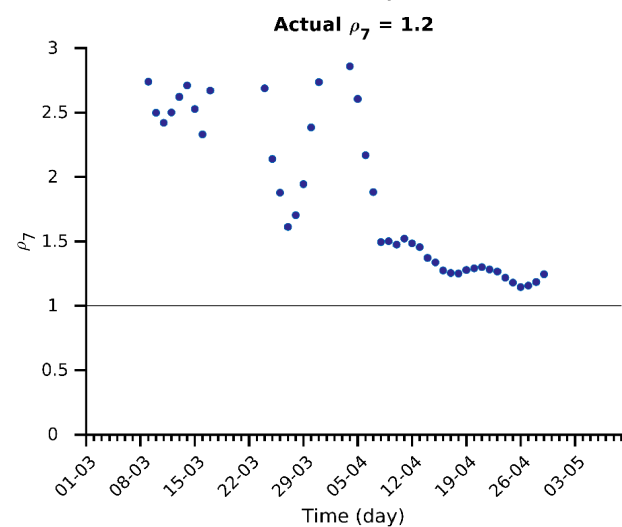
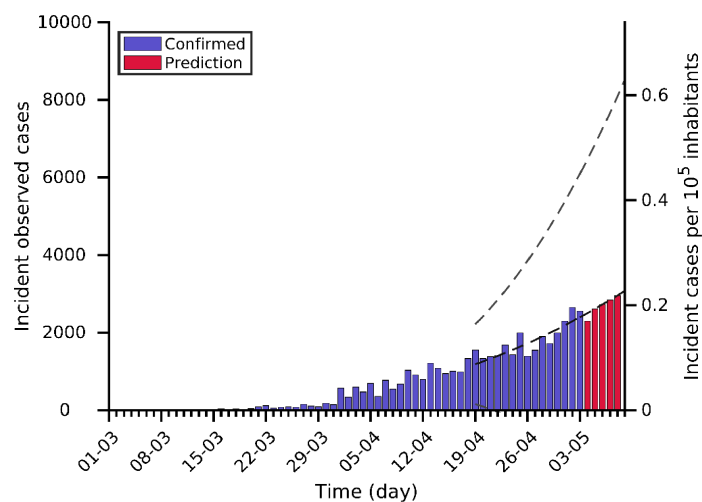
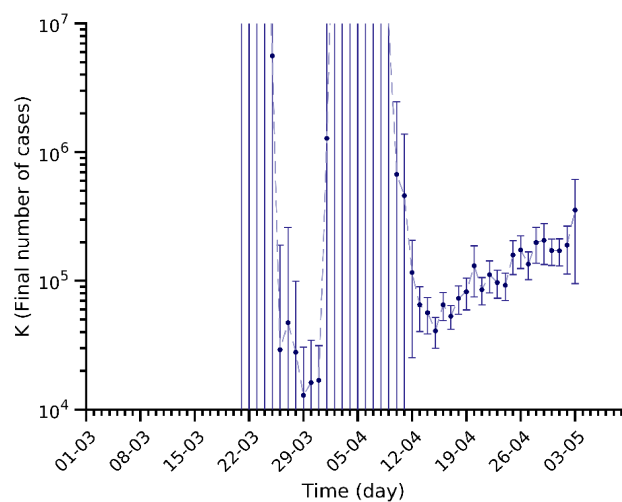
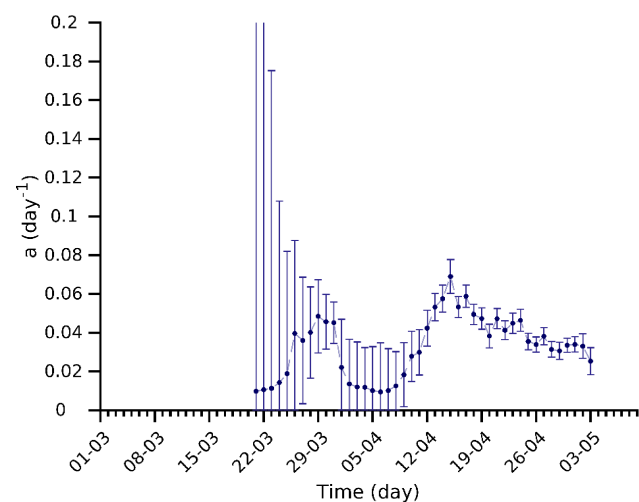
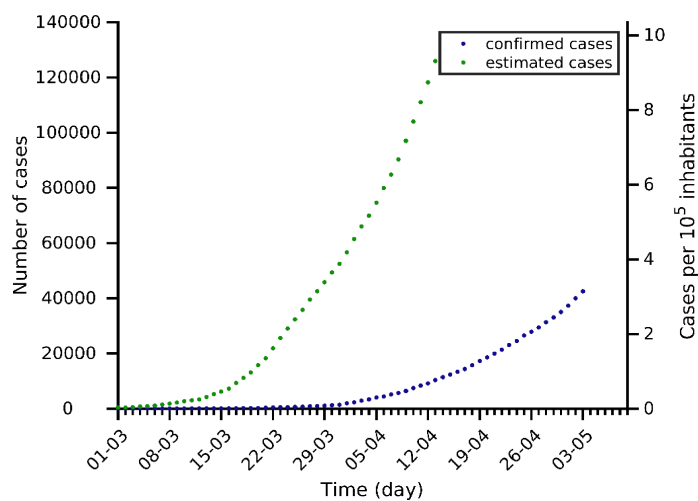
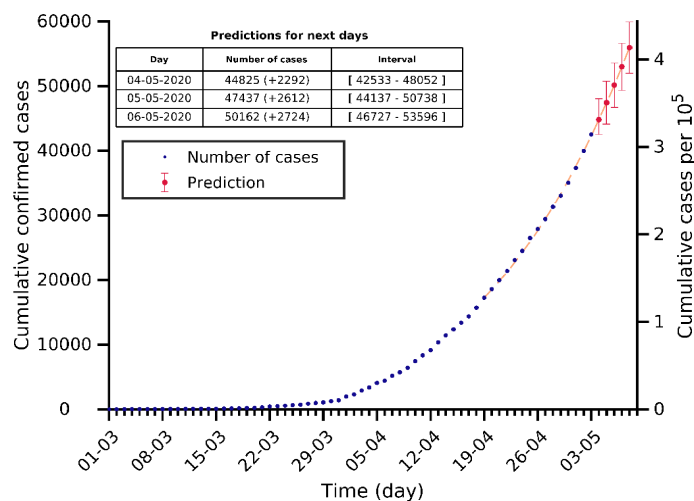
Canada 03-05-2020. Population: 37.7M. Current cumulated incidence: 158/10⁵



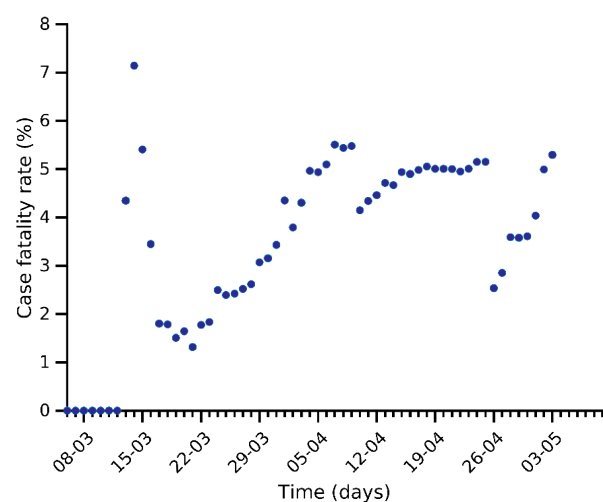
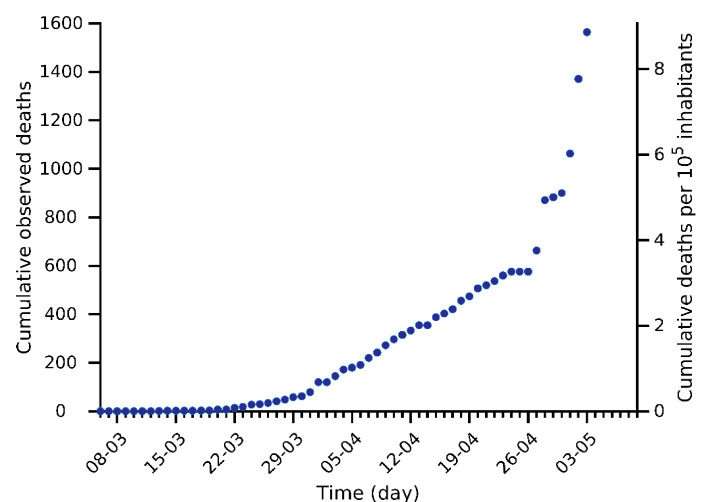
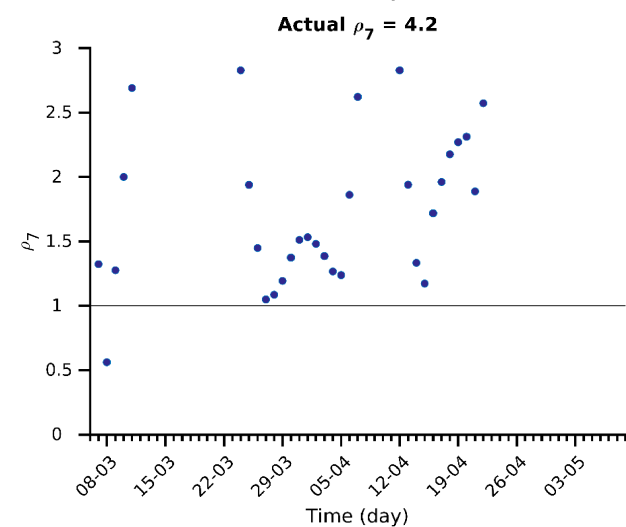
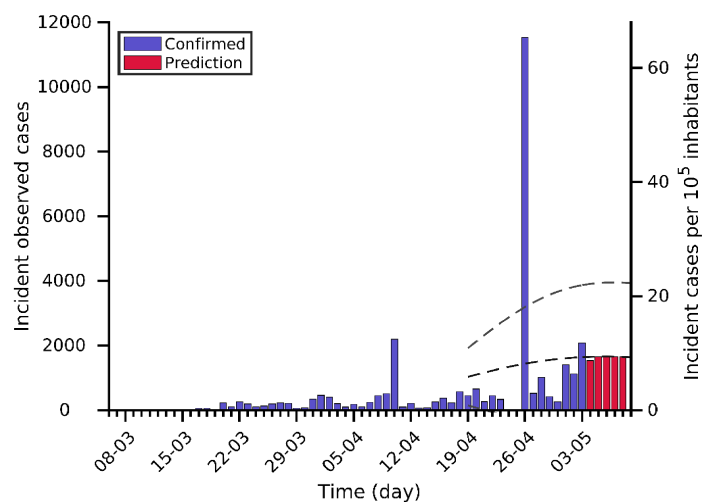
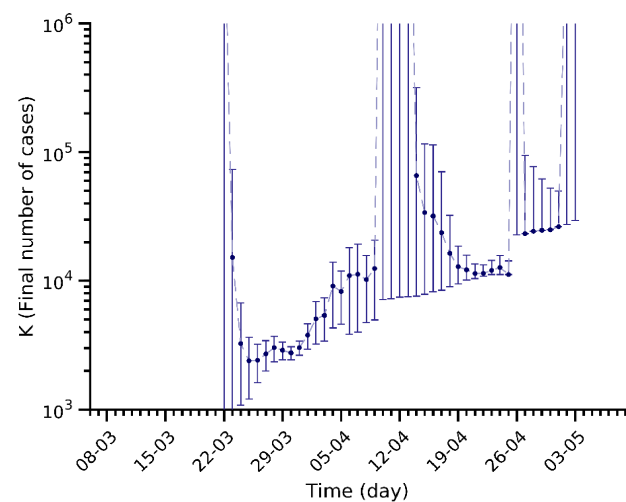
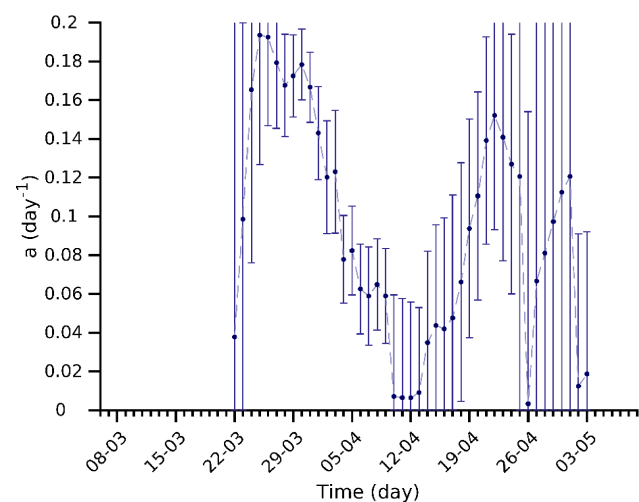
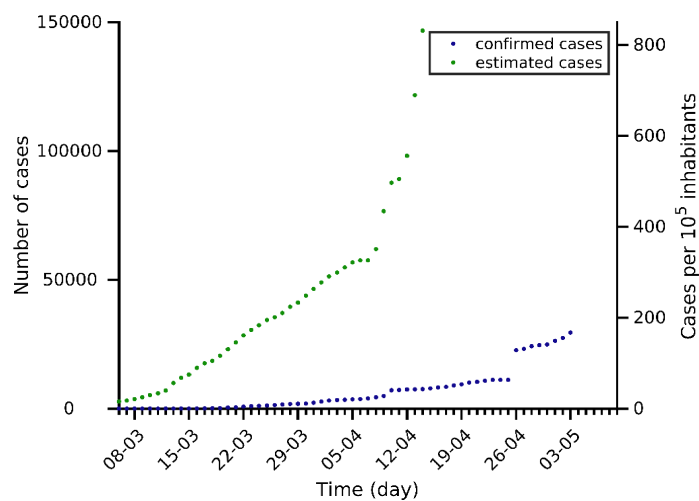
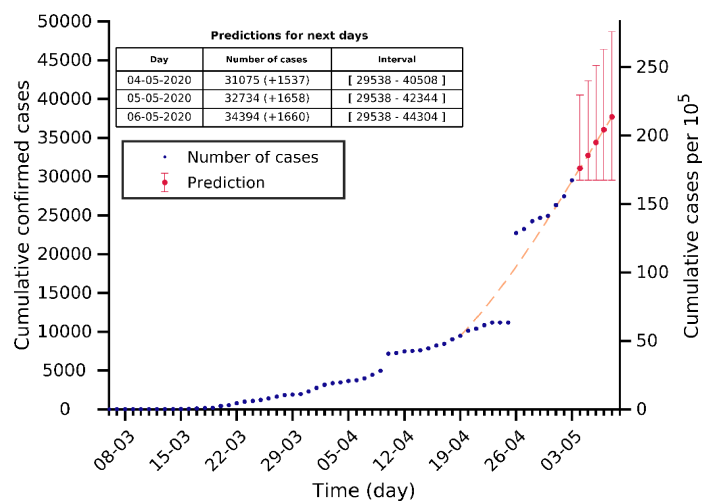
Peru 03-05-2020. Population: 33.0M. Current cumulated incidence: 139/10⁵



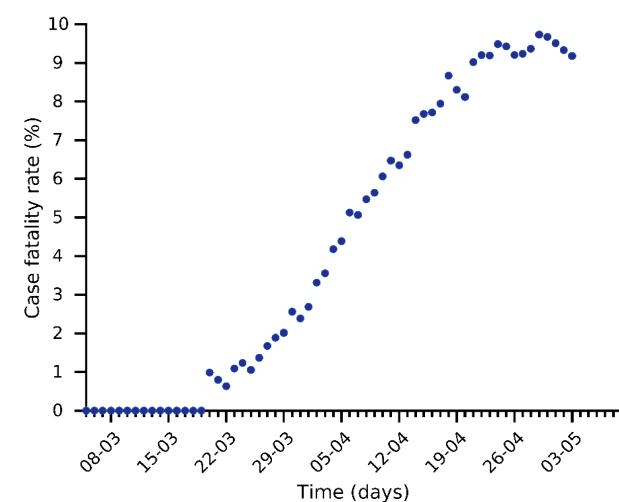
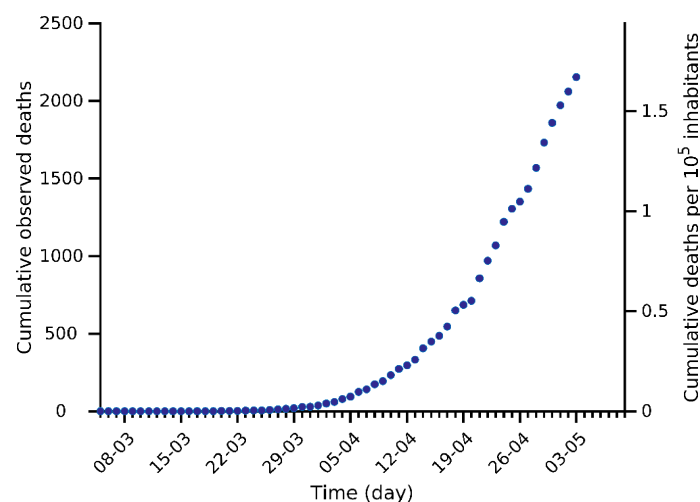
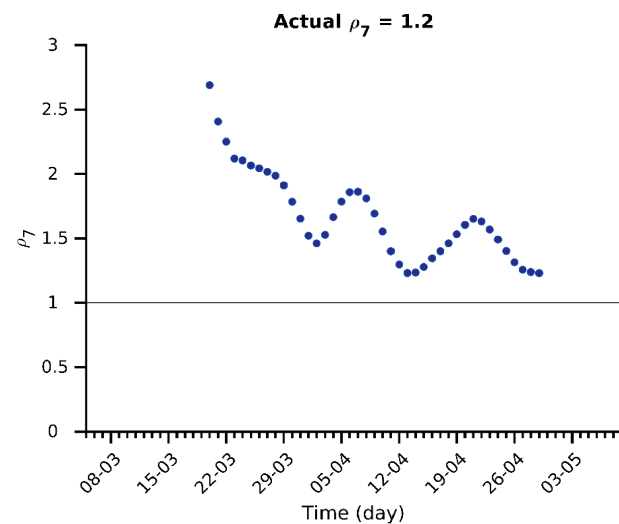
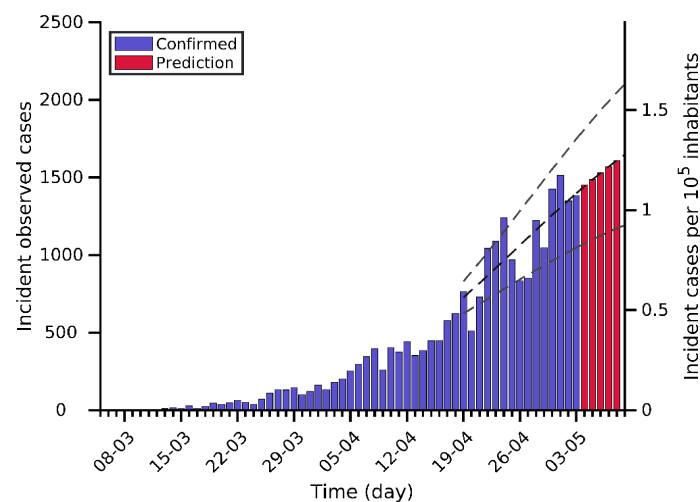
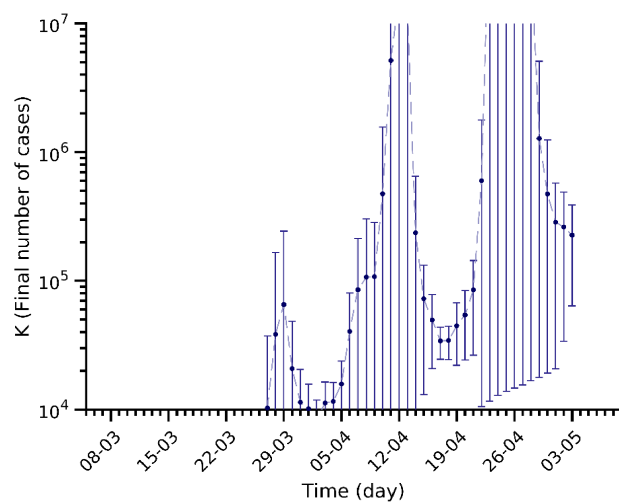
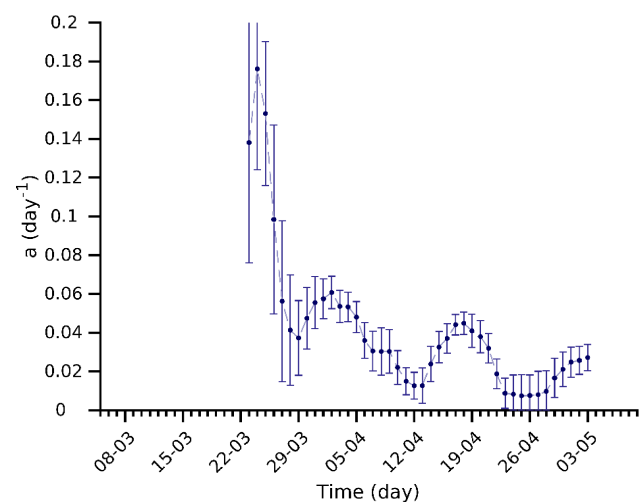
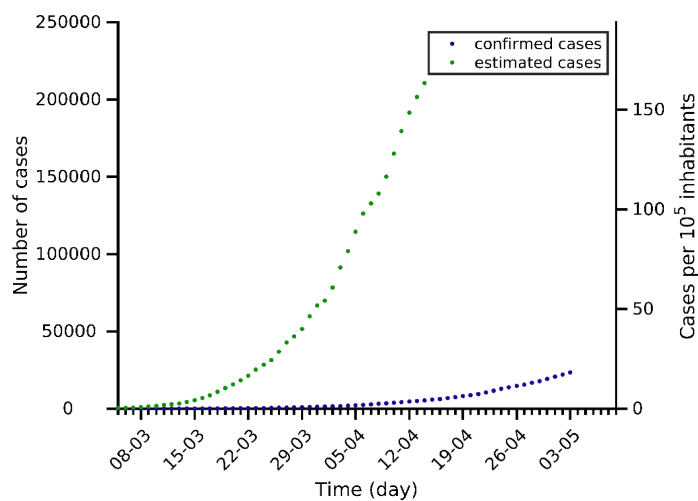
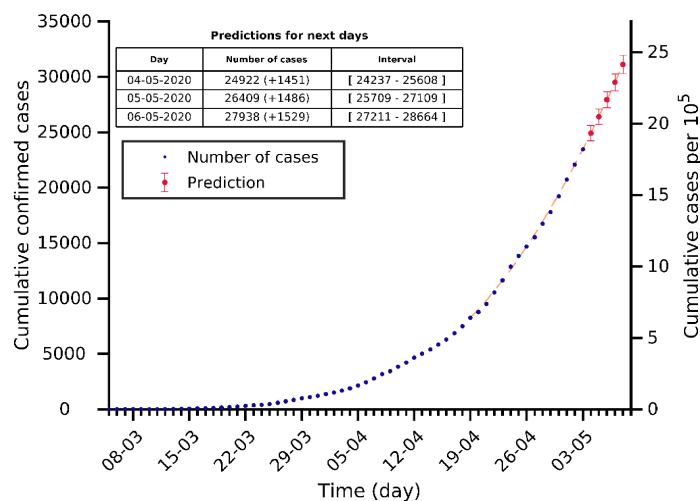
India 03-05-2020. Population: 1353.0M. Current cumulated incidence: 3/10⁵



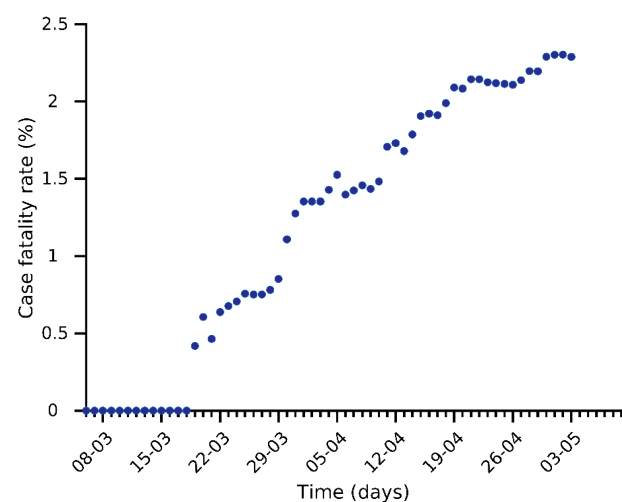
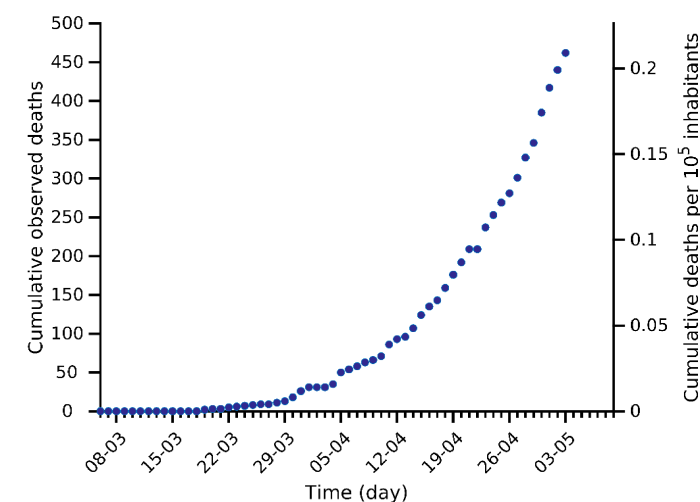
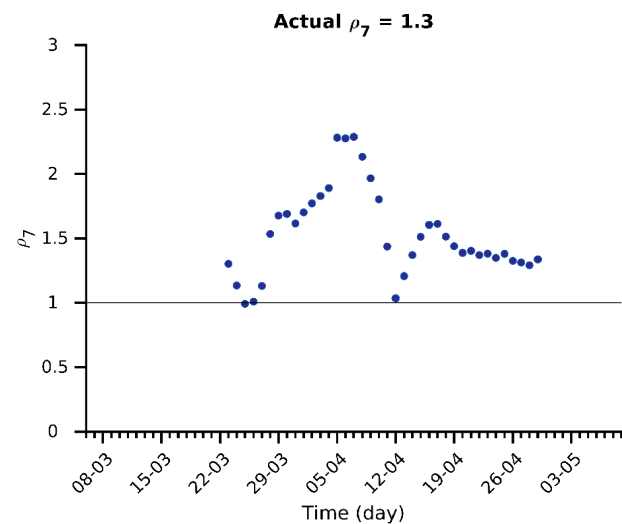
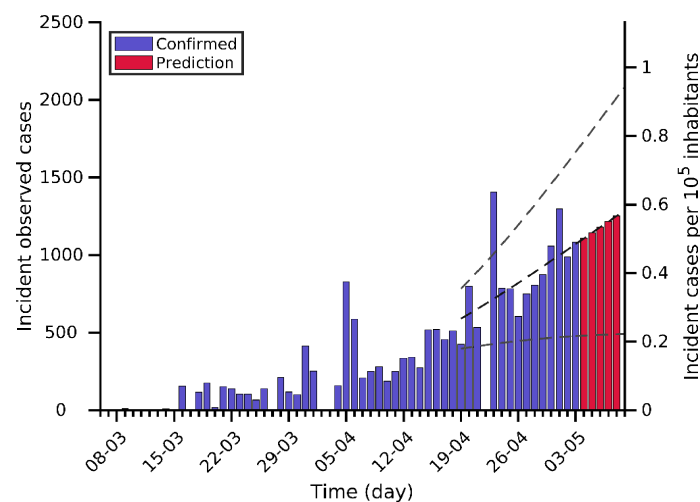
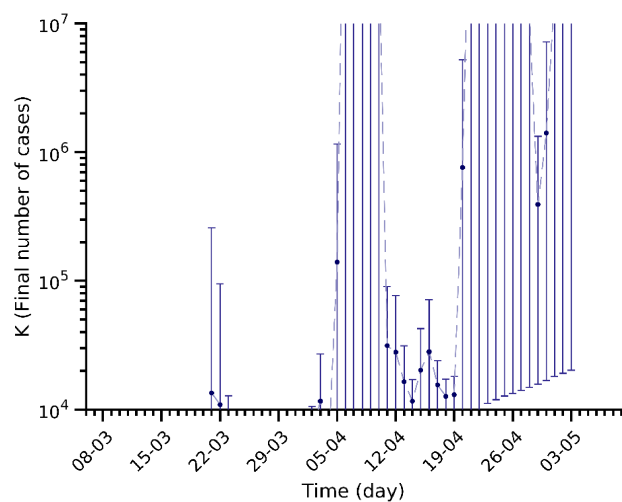
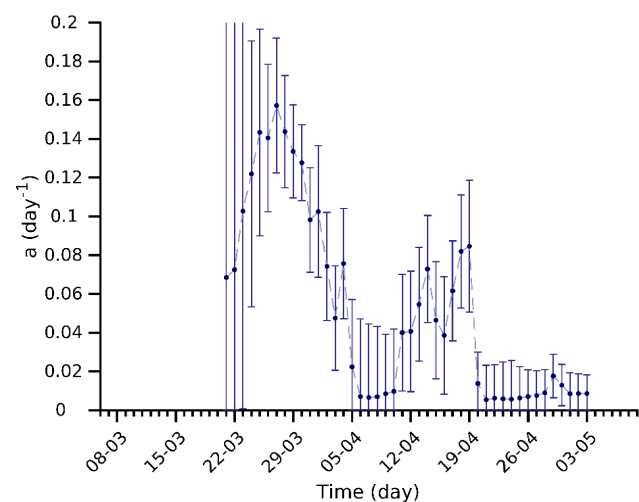
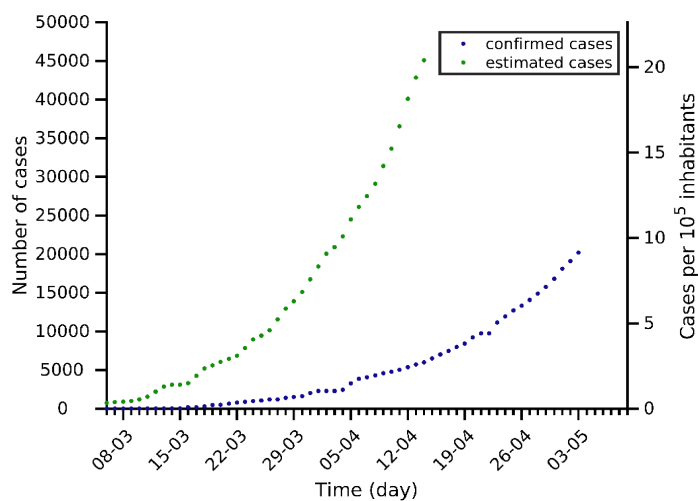
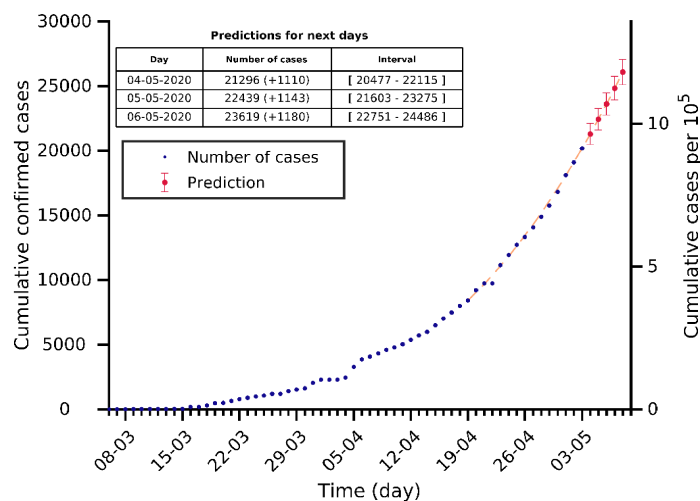
Ecuador 03-05-2020. Population: 17.6M. Current cumulated incidence: 167/10⁵



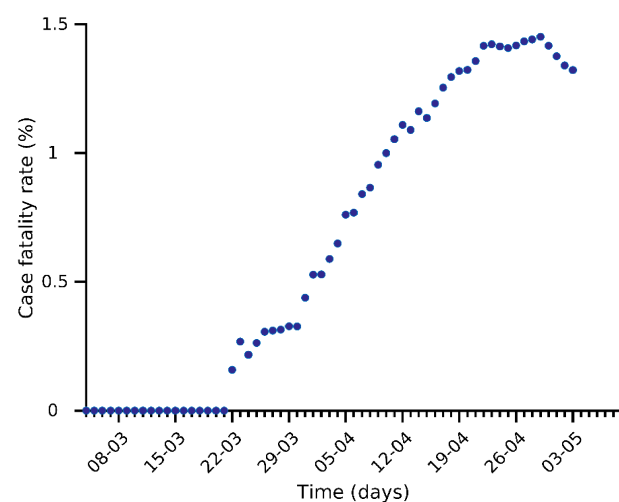
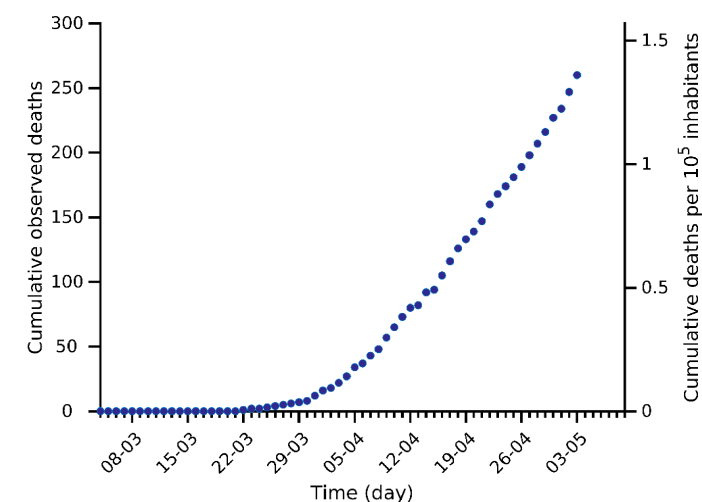
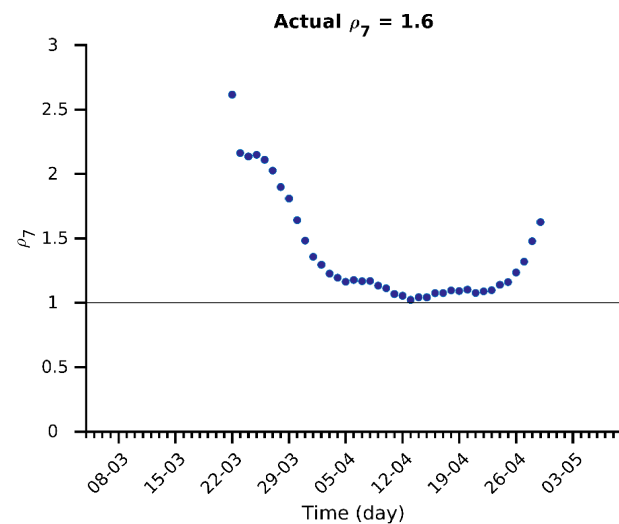
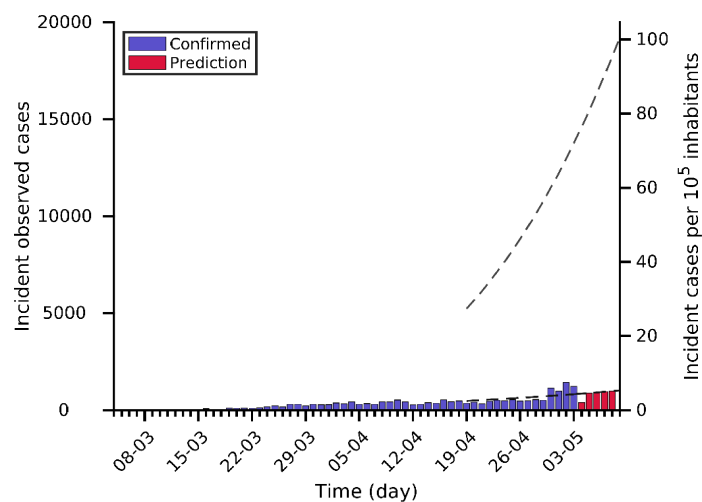
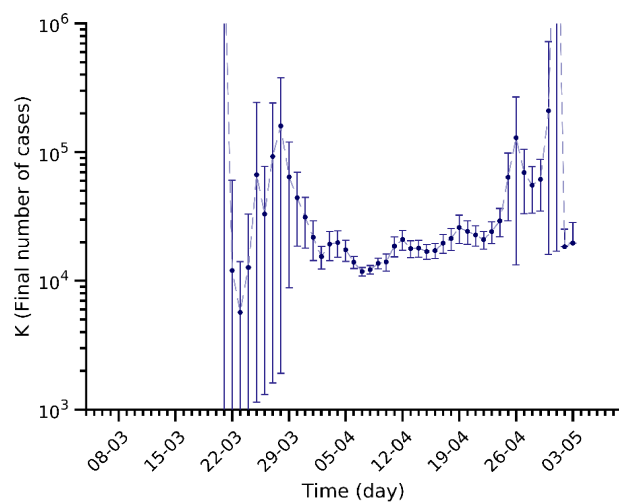
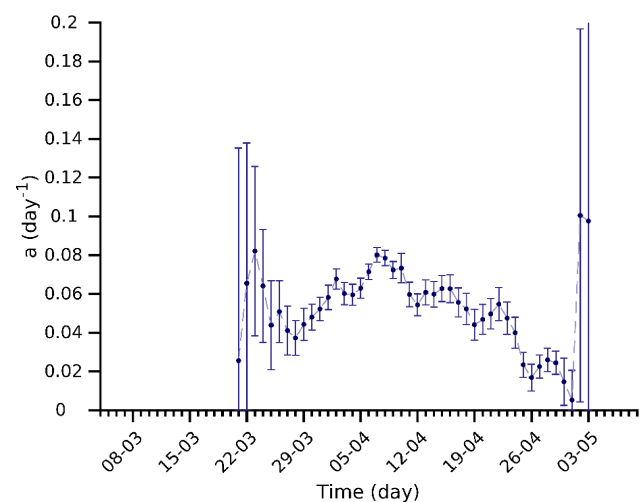
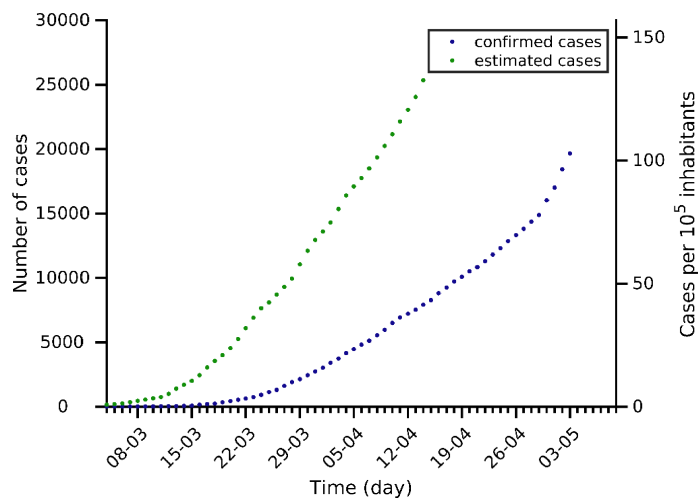
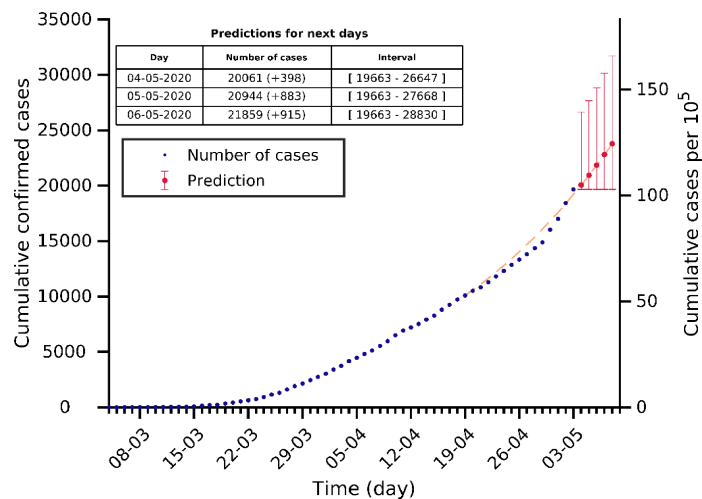
Mexico 03-05-2020. Population: 128.9M. Current cumulated incidence: 18/10⁵



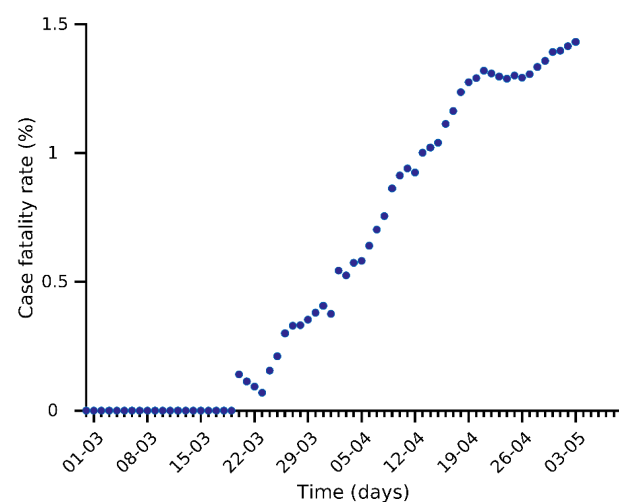
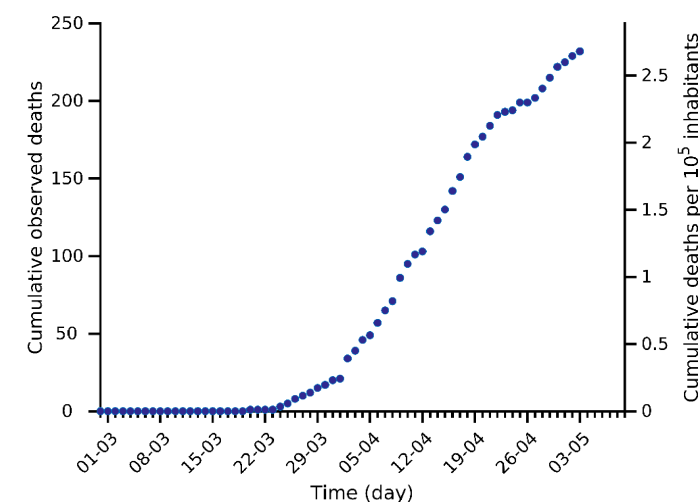
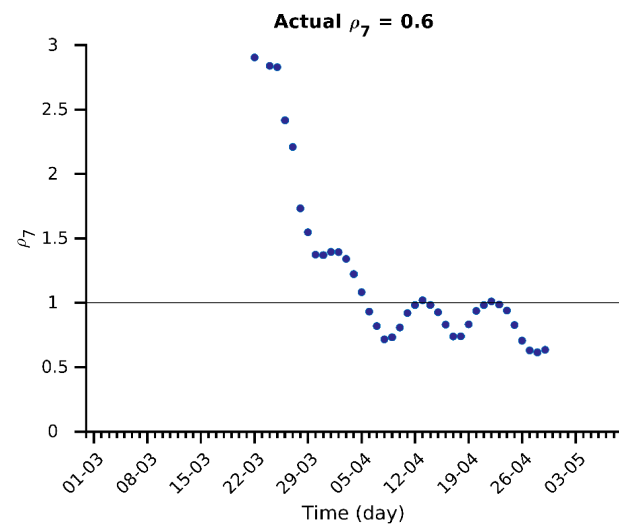
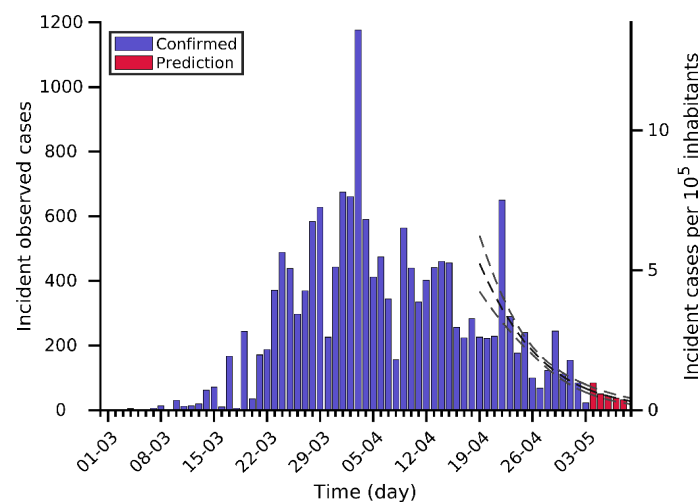
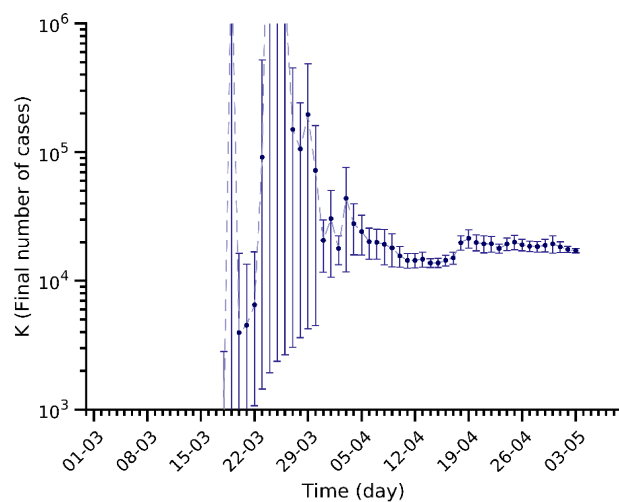
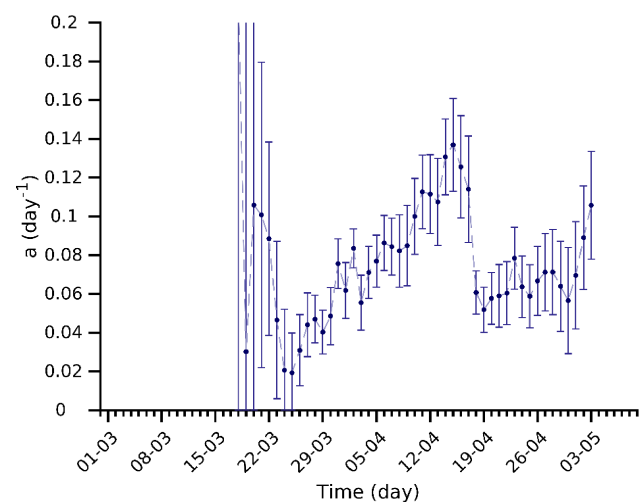
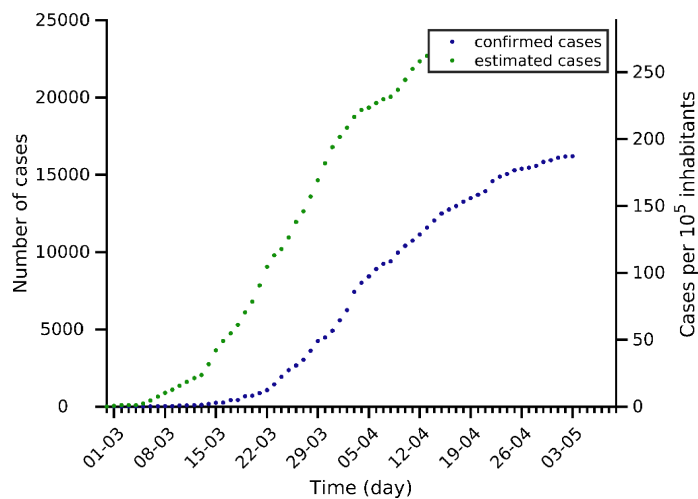
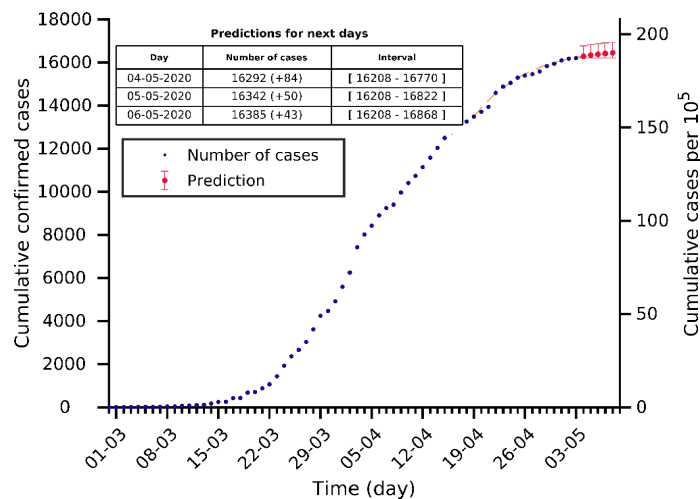
Pakistan 03-05-2020. Population: 220.9M. Current cumulated incidence: 9/10⁵



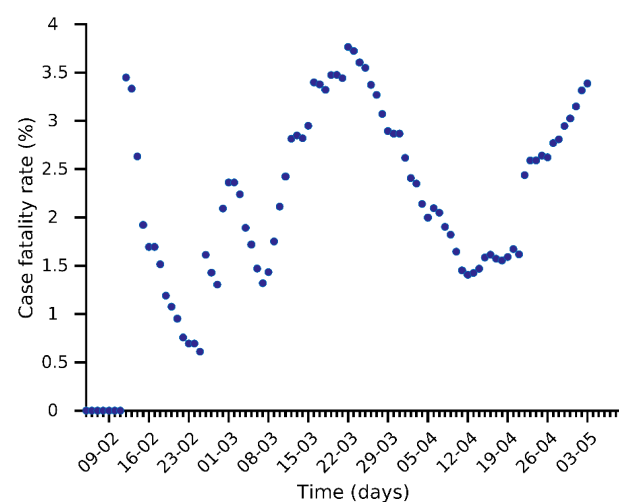
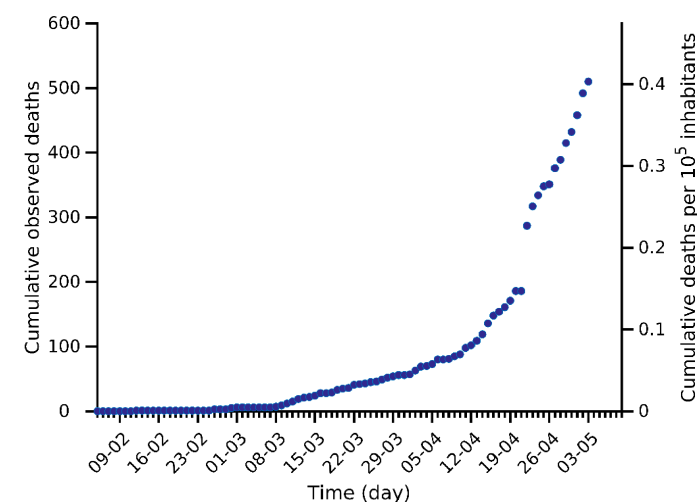
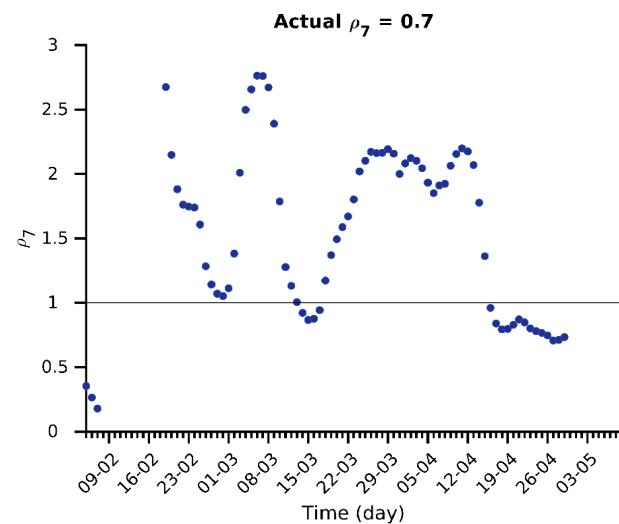
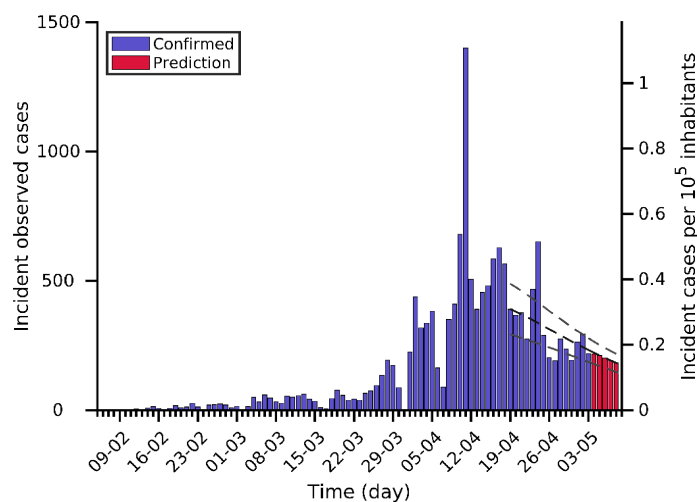
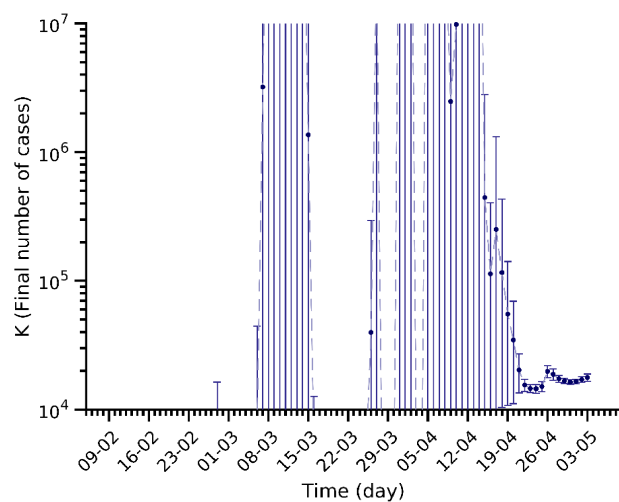
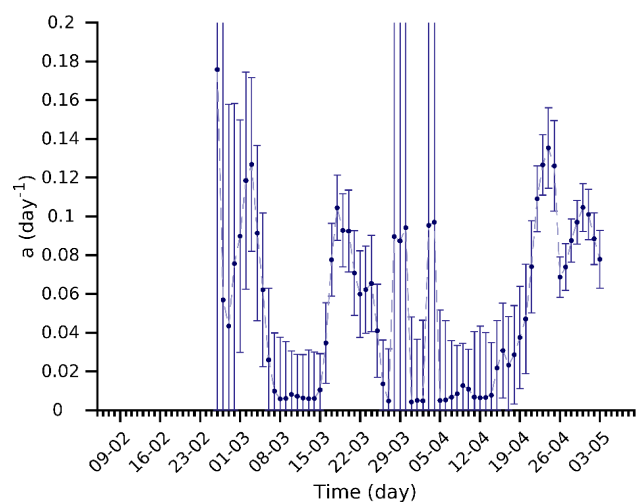
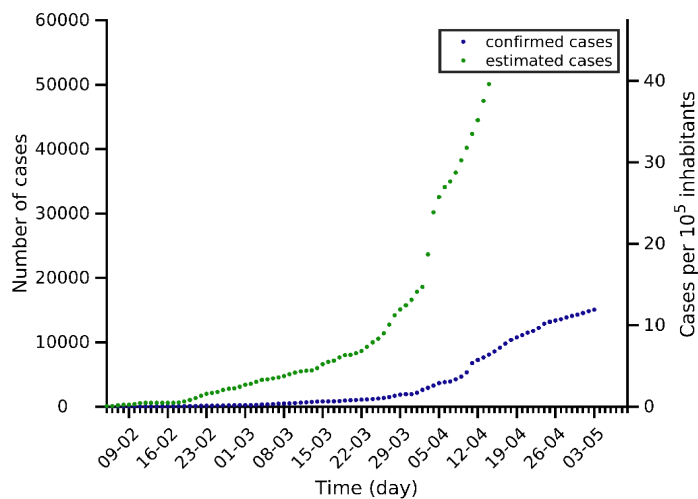
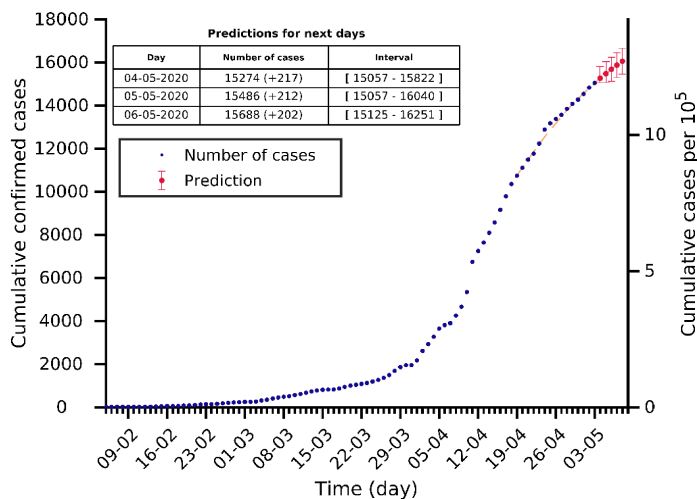
Chile 03-05-2020. Population: 19.1M. Current cumulated incidence: 103/10⁵



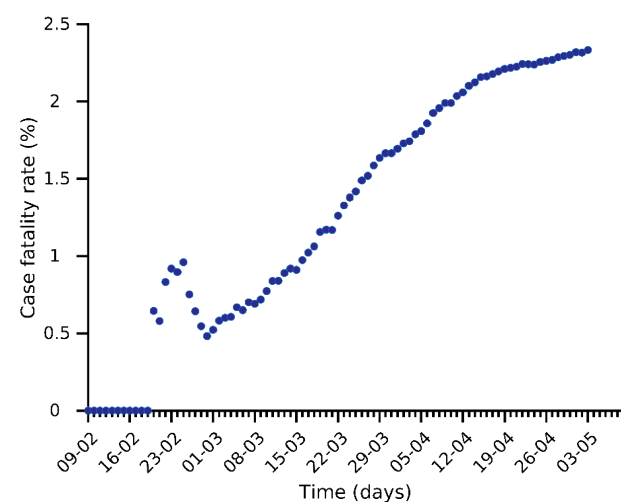
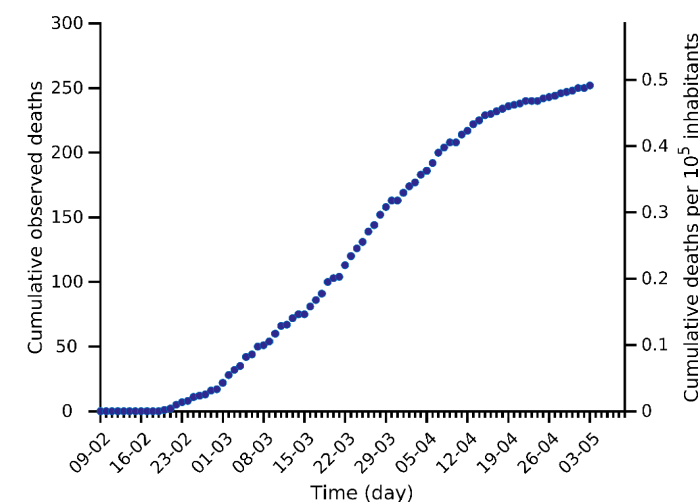
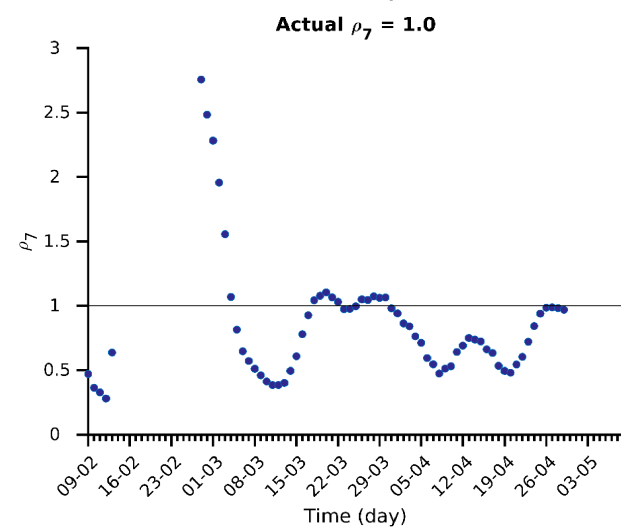
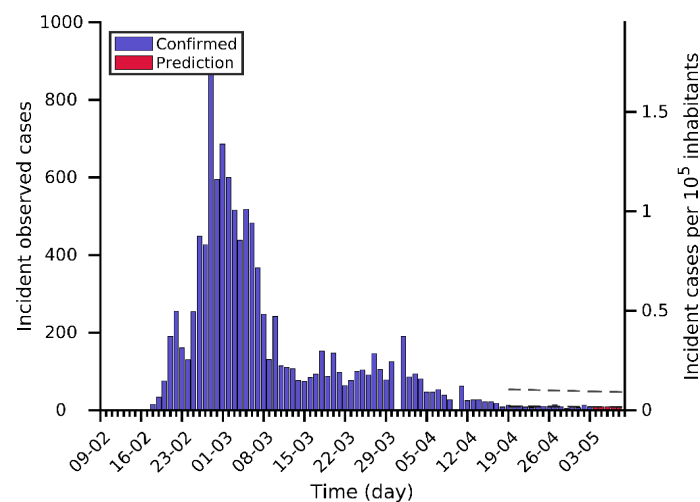
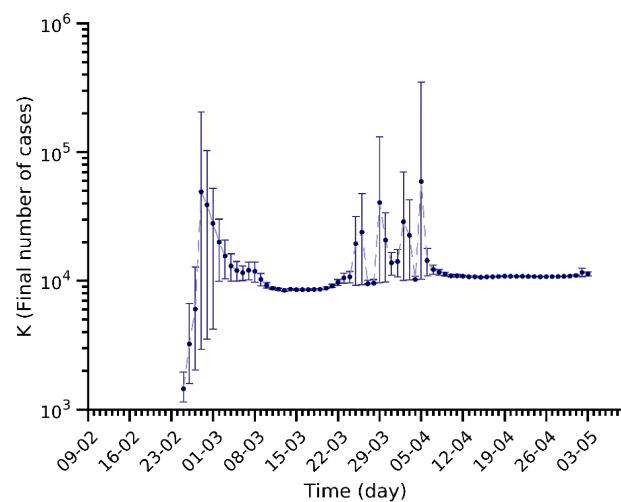
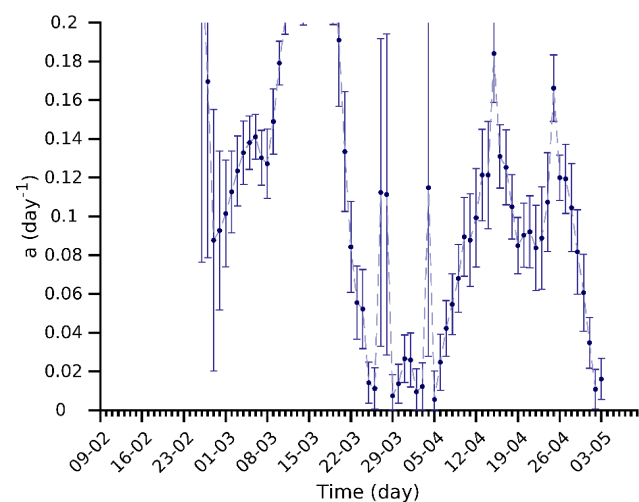
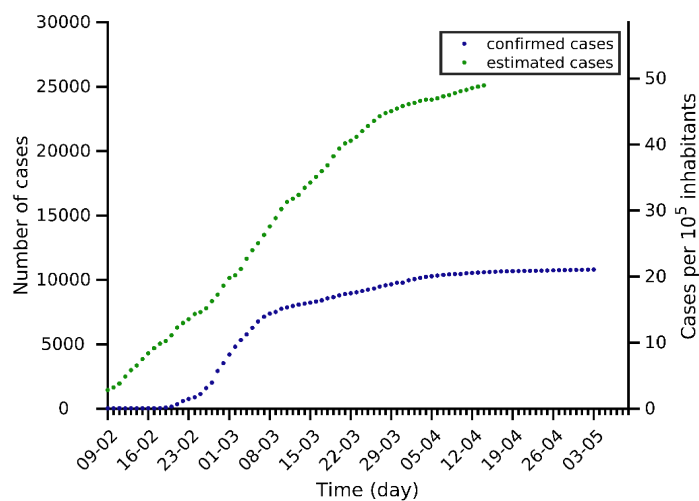
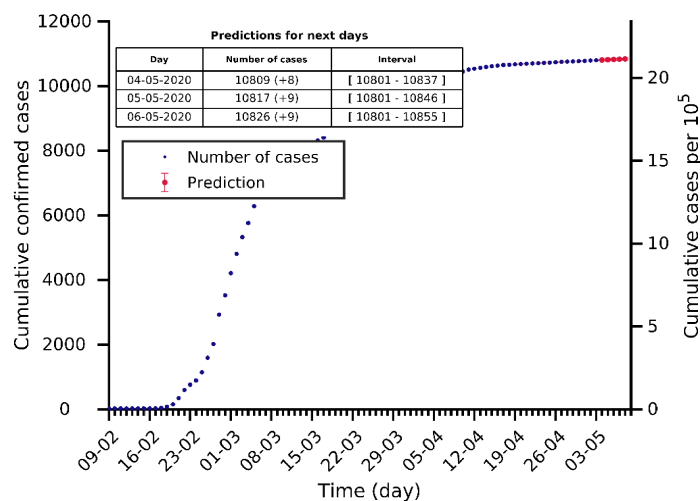
Israel 03-05-2020. Population: 8.7M. Current cumulated incidence: 187/10⁵



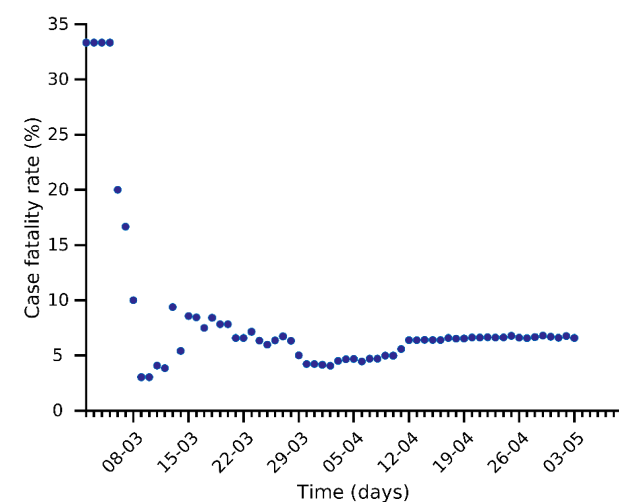
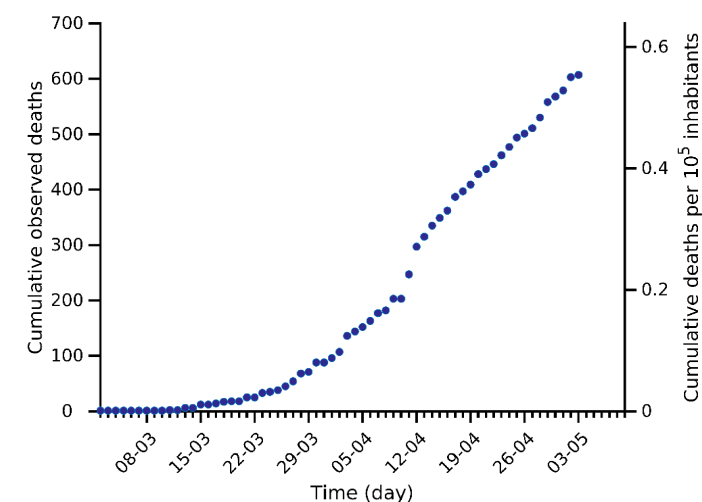
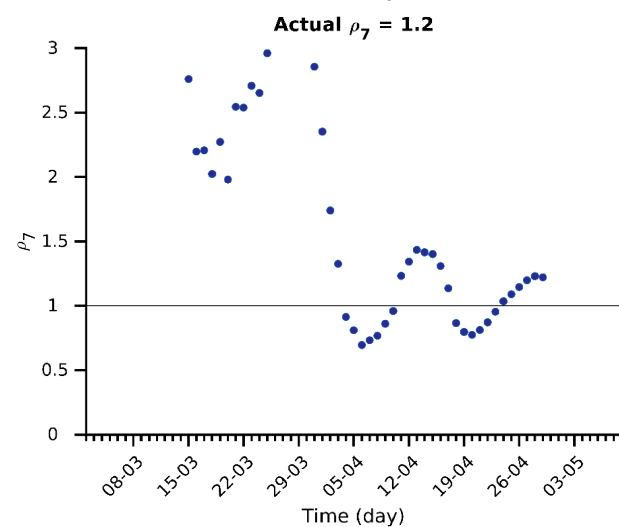
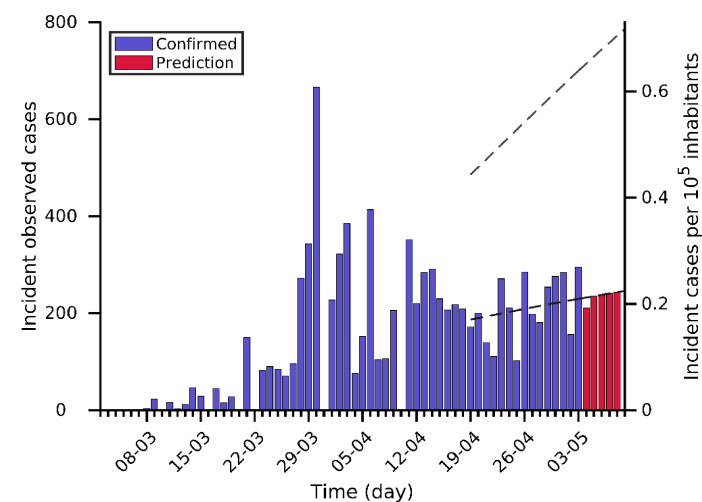
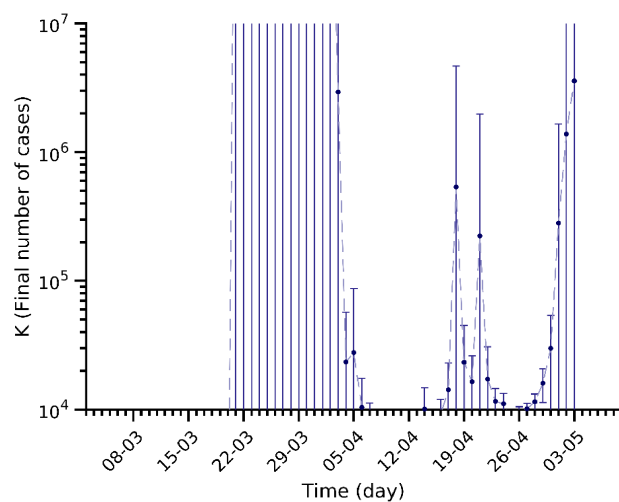
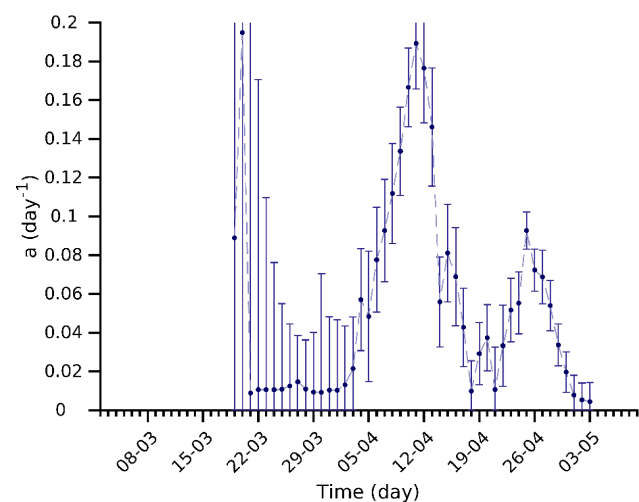
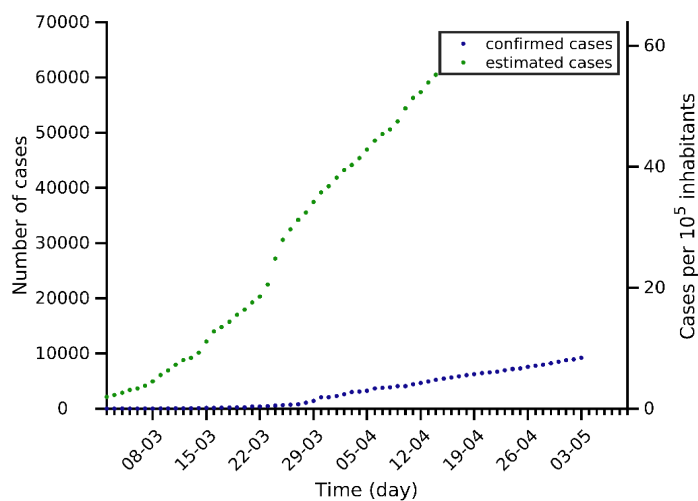
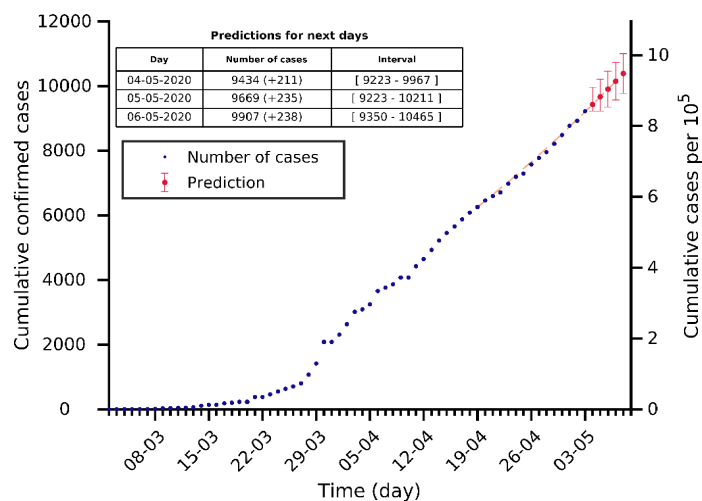
Japan 03-05-2020. Population: 126.5M. Current cumulated incidence: 12/10⁵



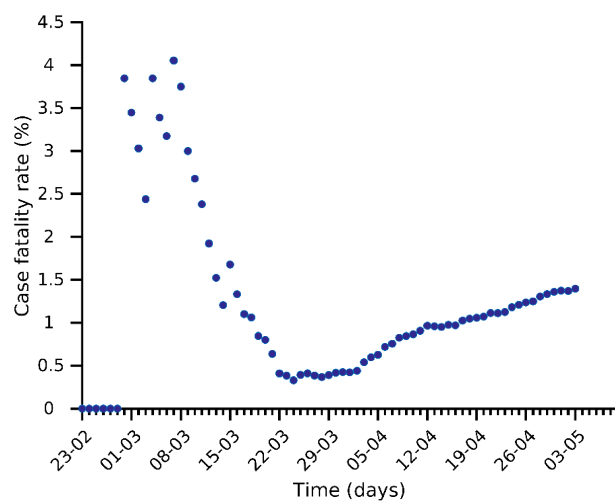
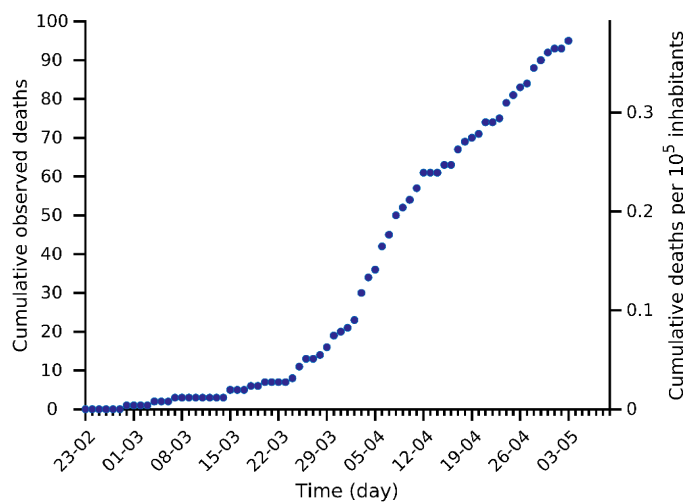
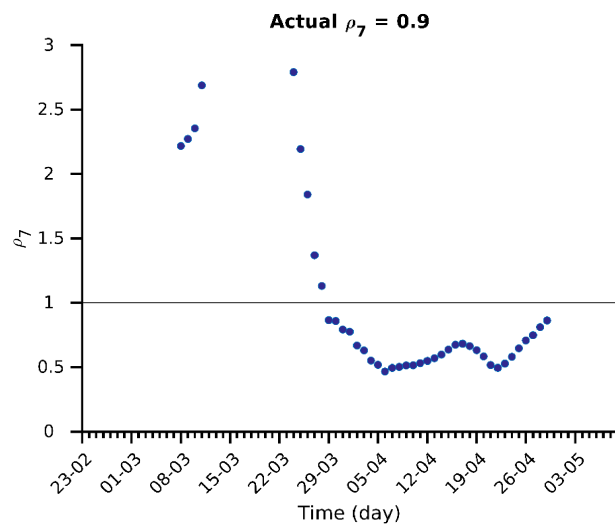
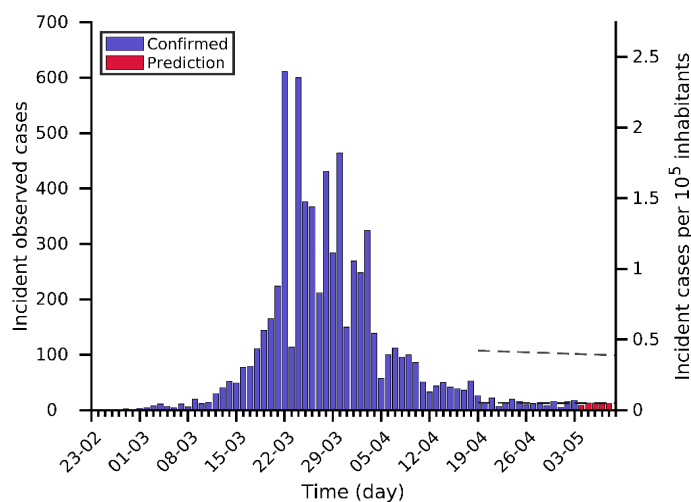
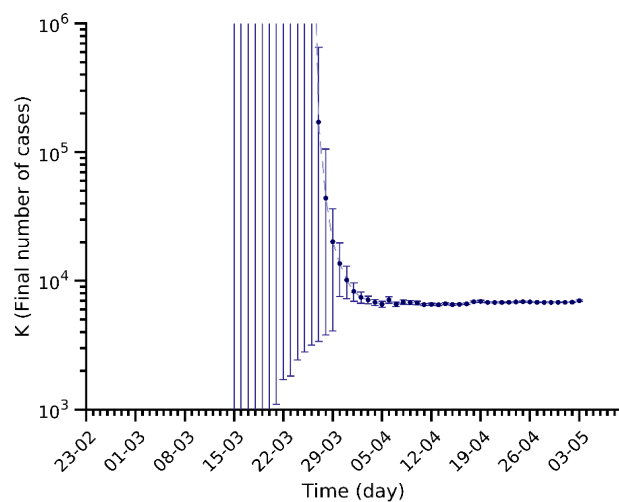
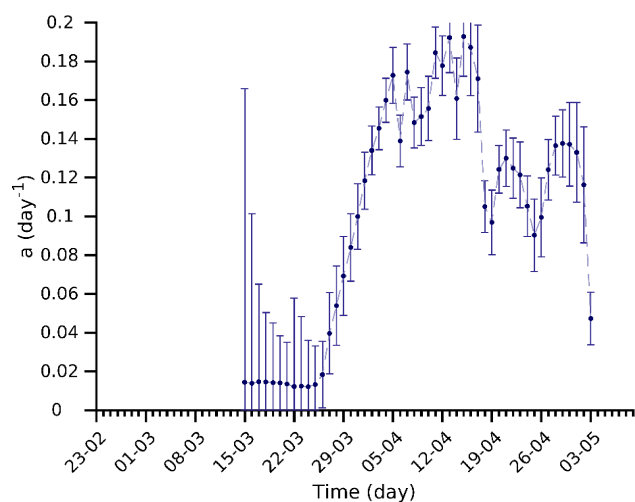
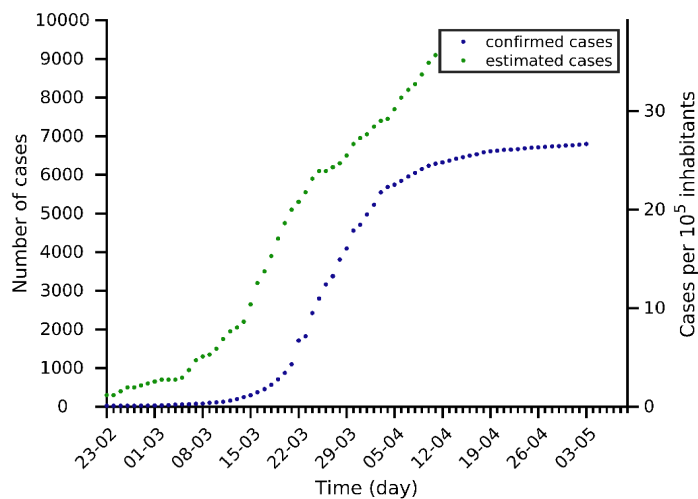
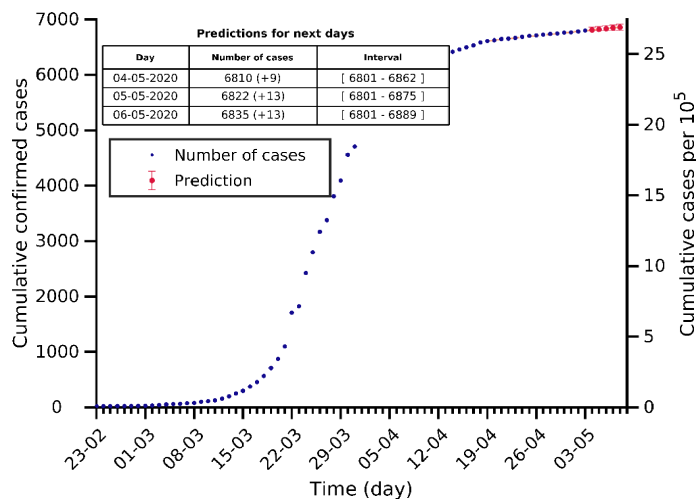
South Korea 03-05-2020. Population: 51.3M. Current cumulated incidence: 21/10⁵



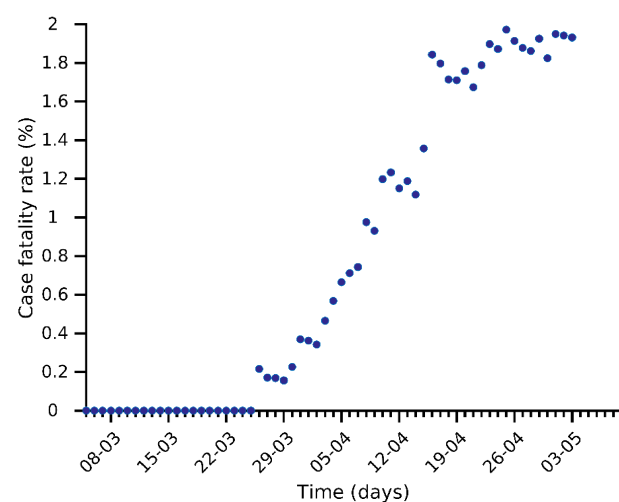
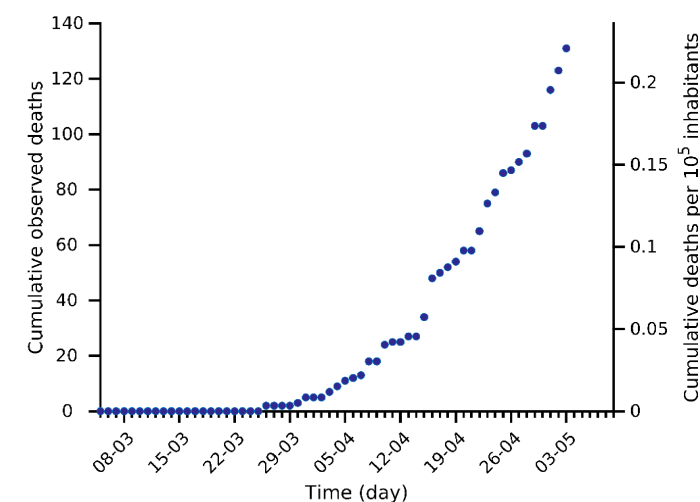
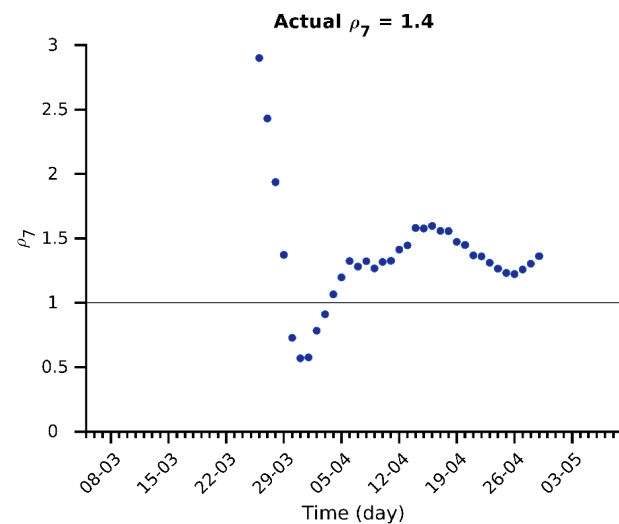
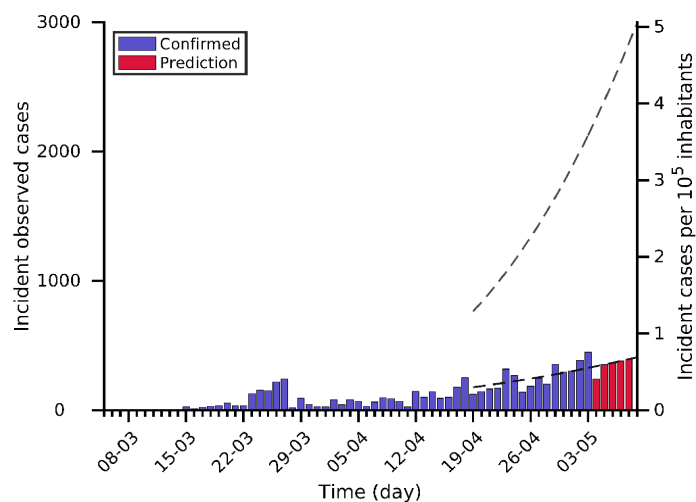
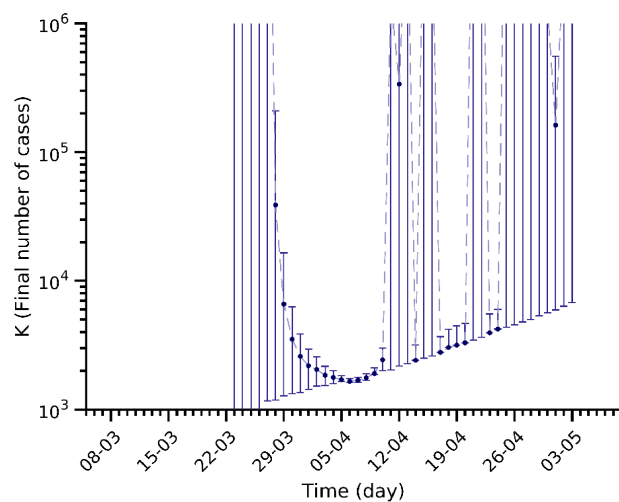
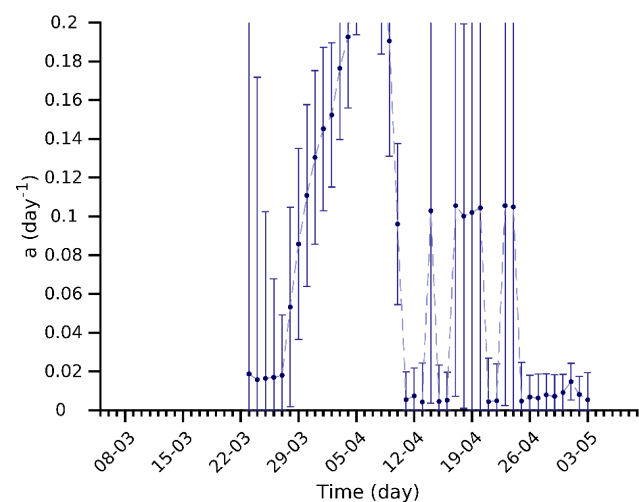
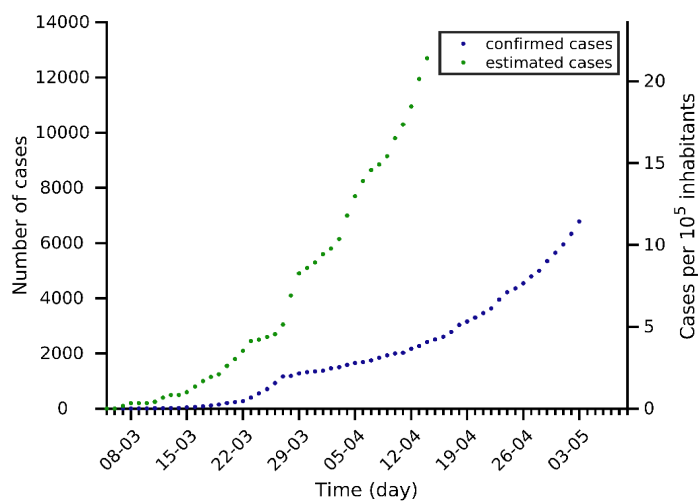
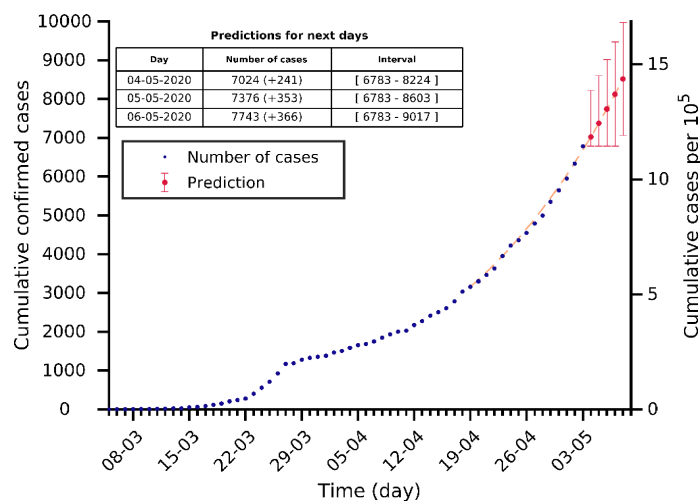
Philippines 03-05-2020. Population: 109.6M. Current cumulated incidence: 8/10⁵



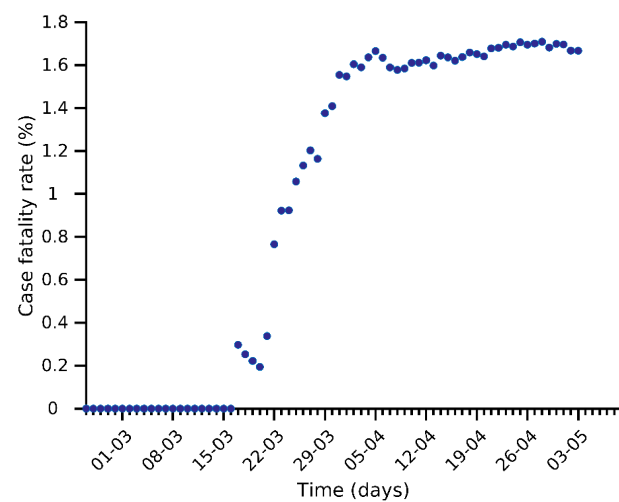
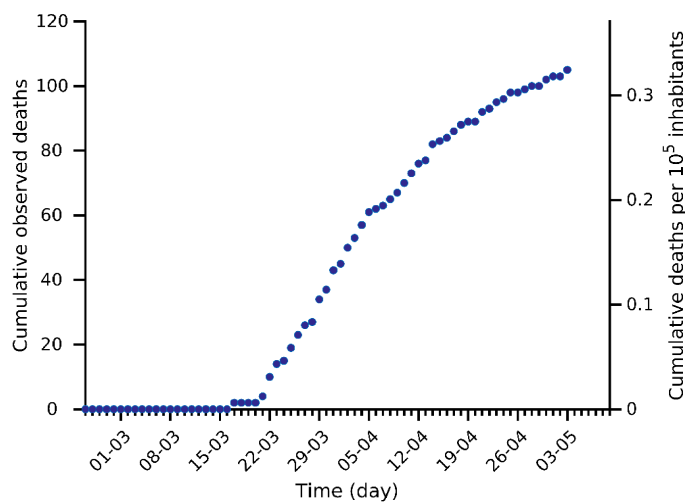
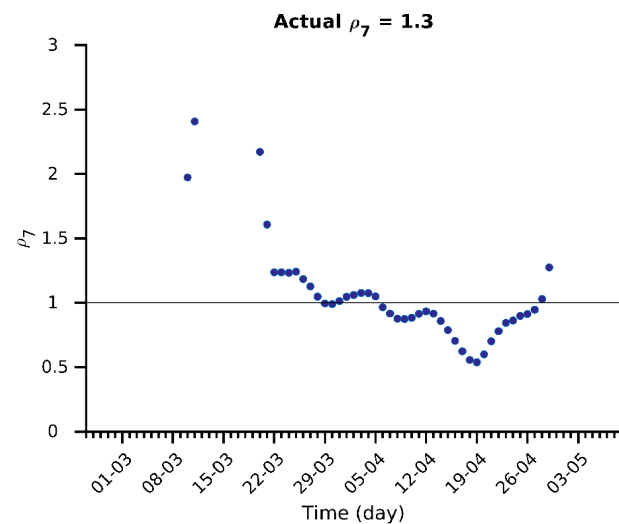
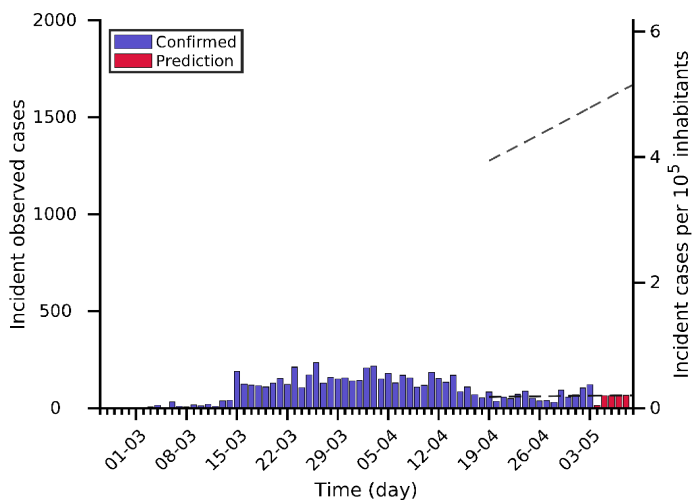
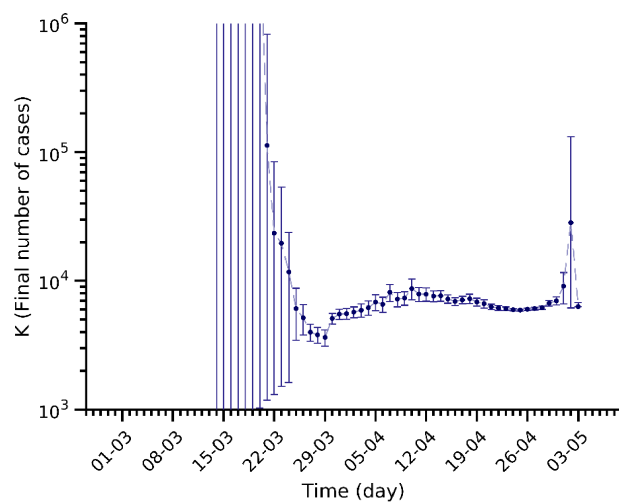
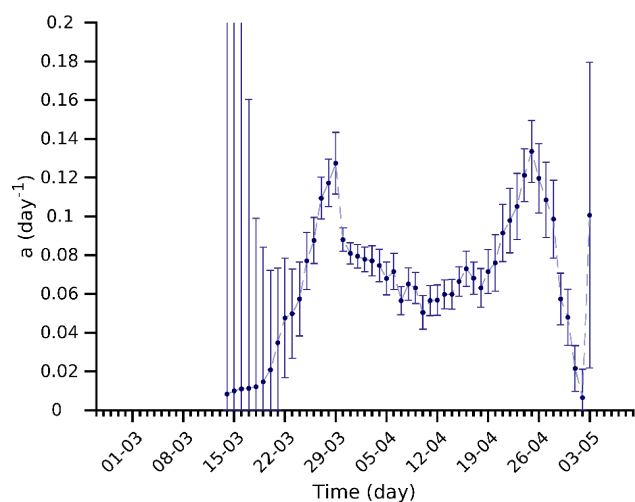
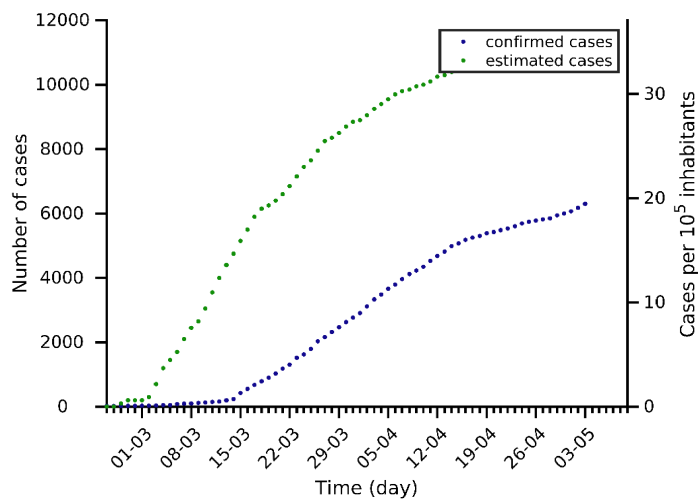
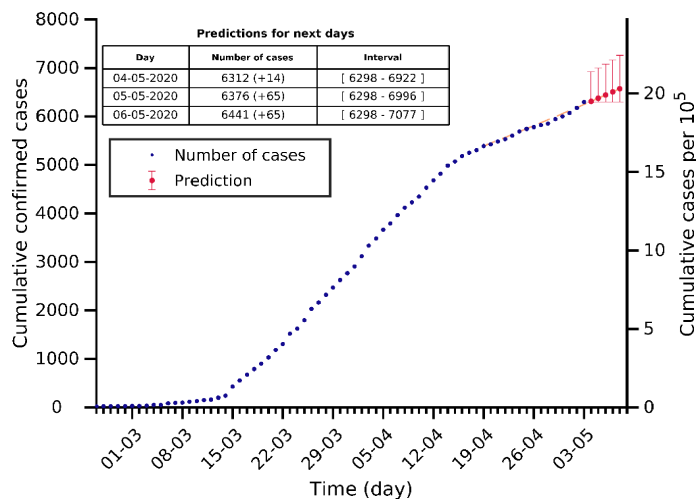
Australia 03-05-2020. Population: 25.5M. Current cumulated incidence: $27/10^5$



South Africa 03-05-2020. Population: 59.3M. Current cumulated incidence: 11/10⁵



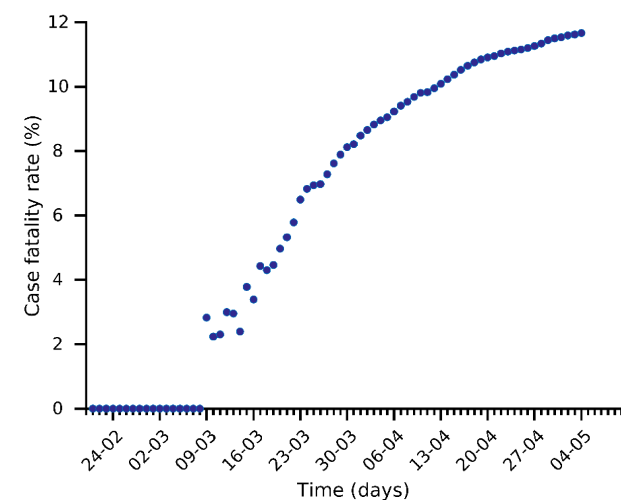
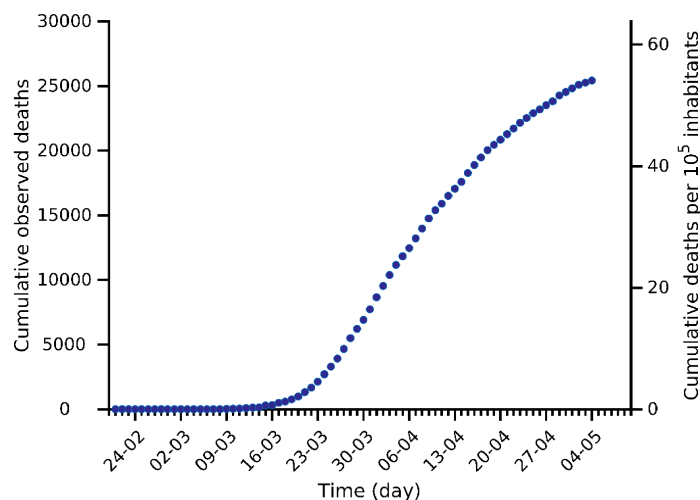
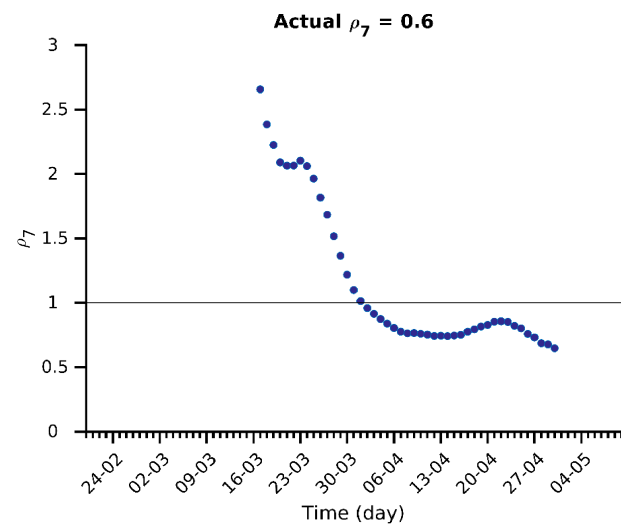
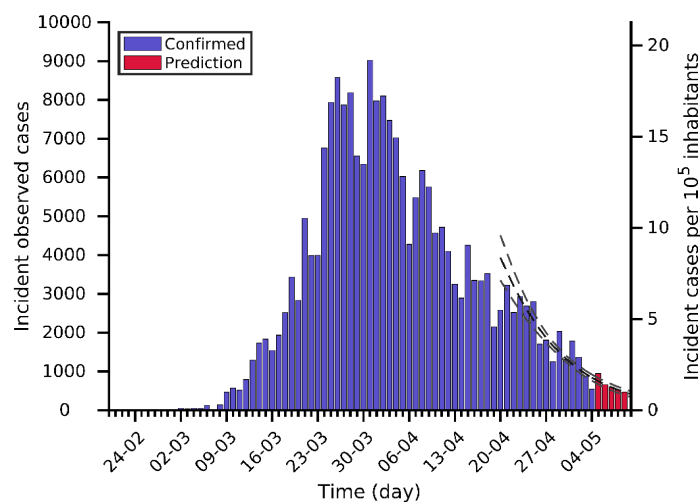
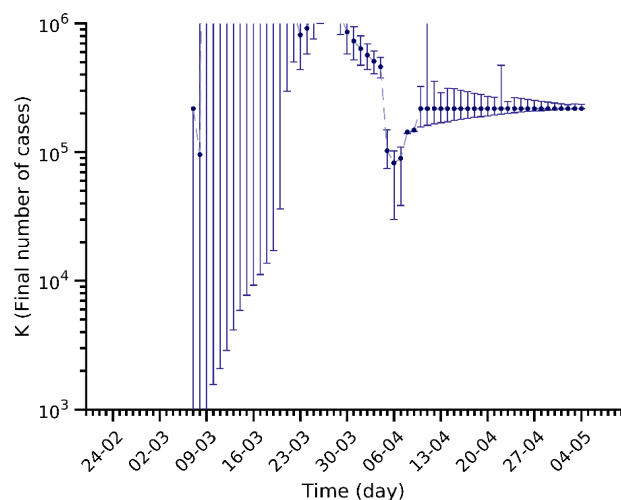
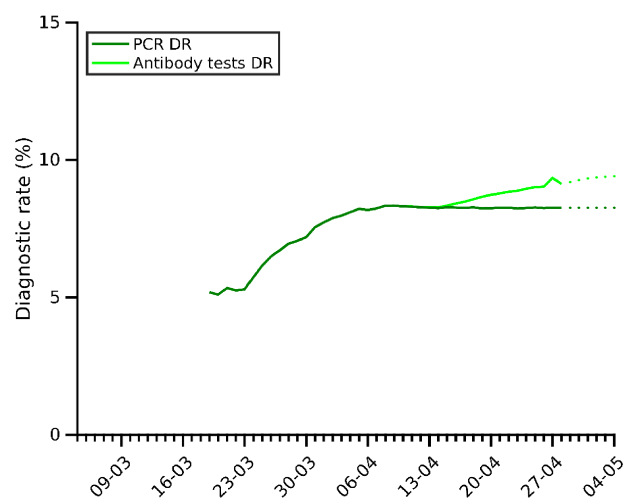
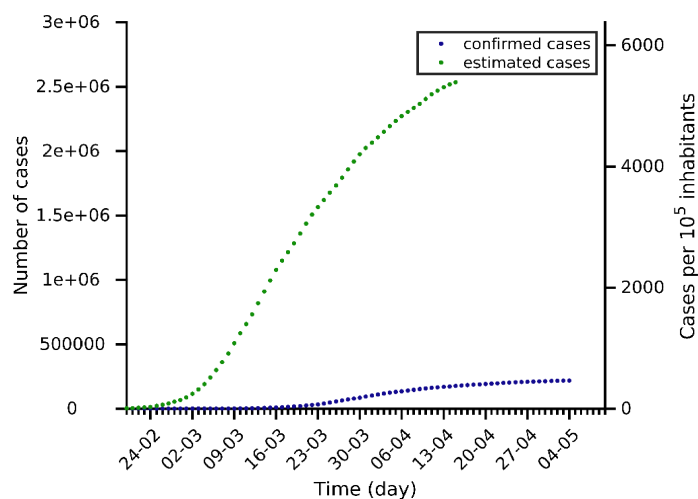
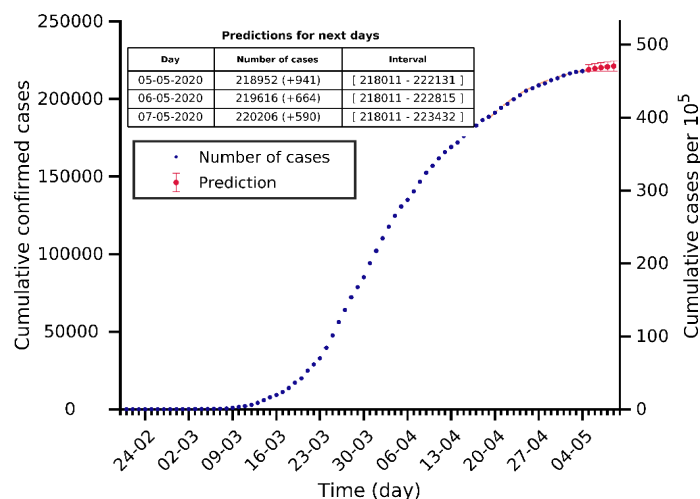
Malaysia 03-05-2020. Population: 32.4M. Current cumulated incidence: 19/10⁵



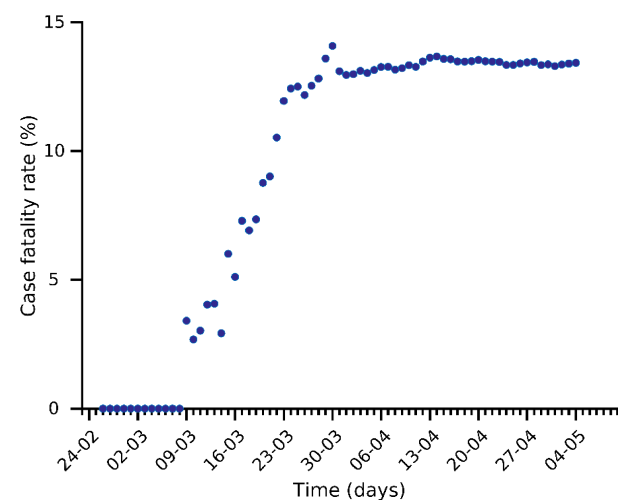
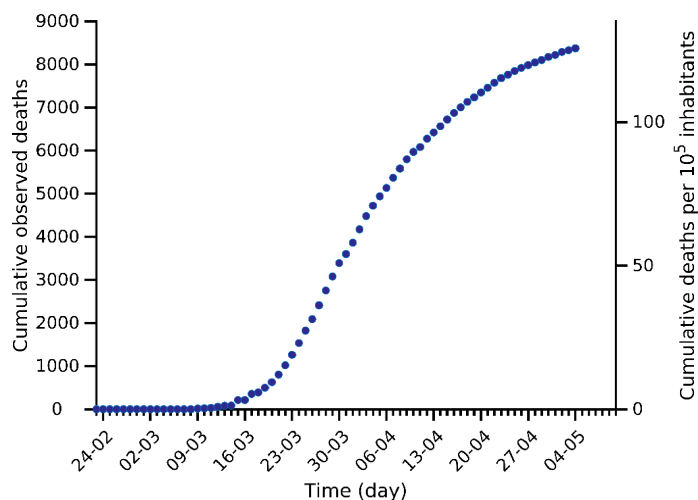
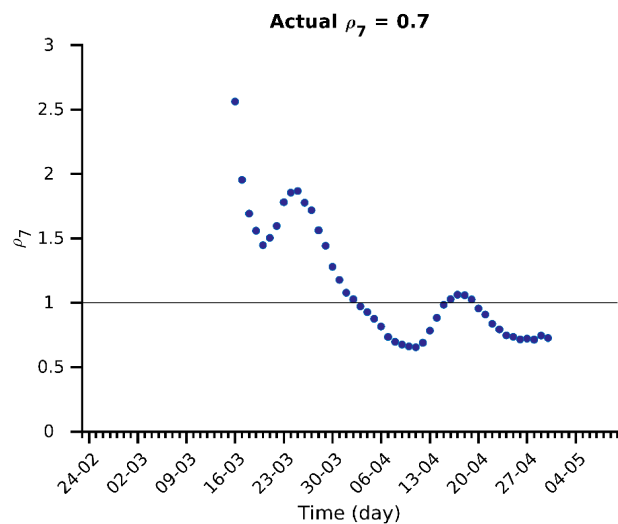
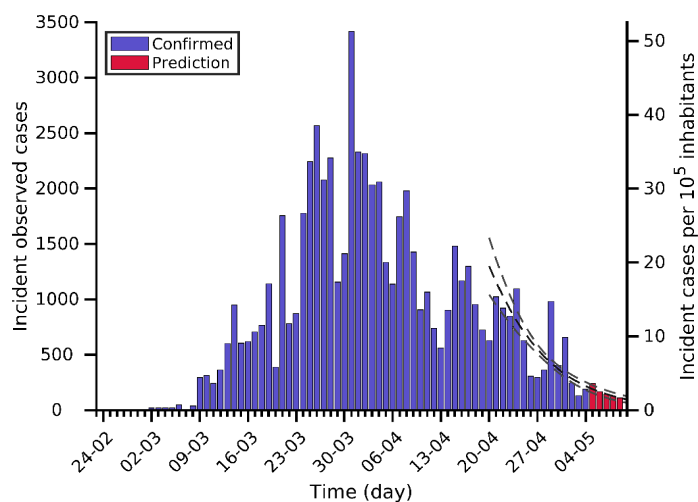
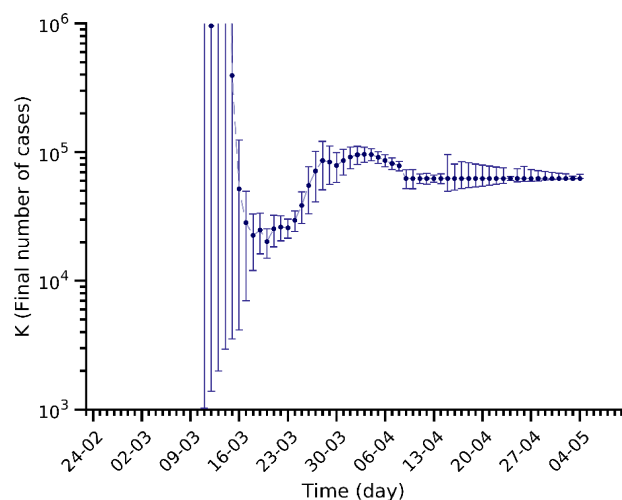
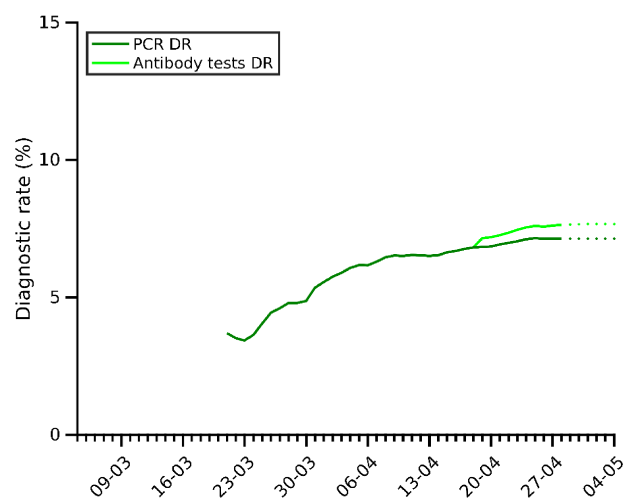
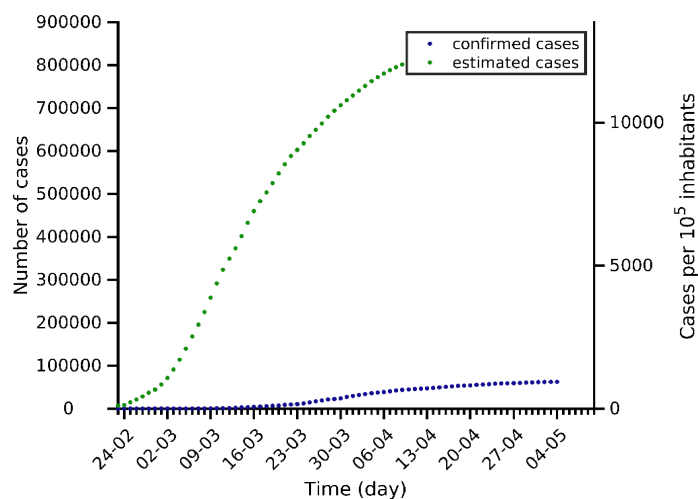
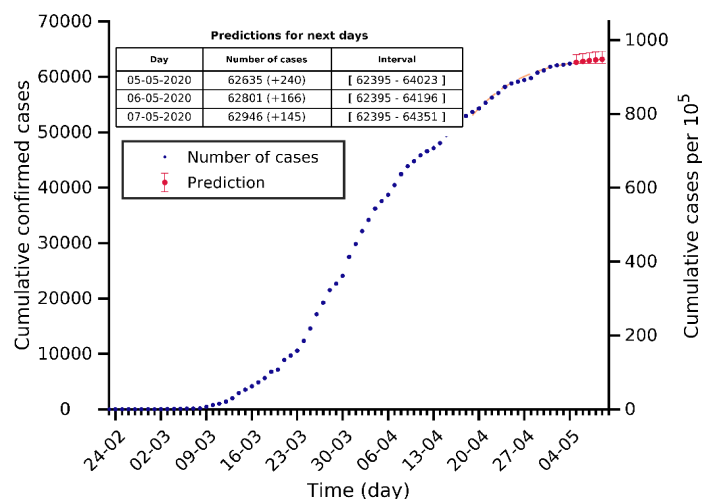
(3) Analysis and prediction of COVID-19 for Spain and its autonomous communities

Data obtained from <https://github.com/datadista/datasets/tree/master/COVID%2019> and
<https://covid19.isciii.es/>

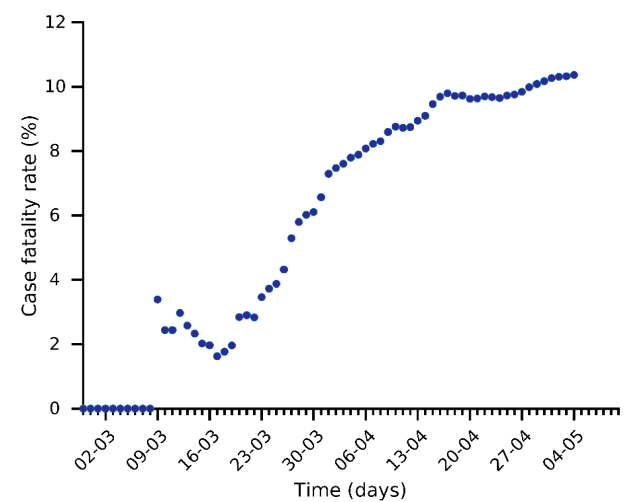
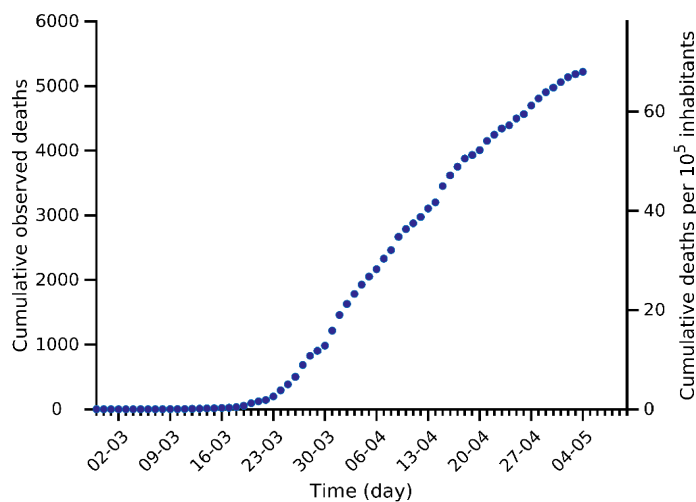
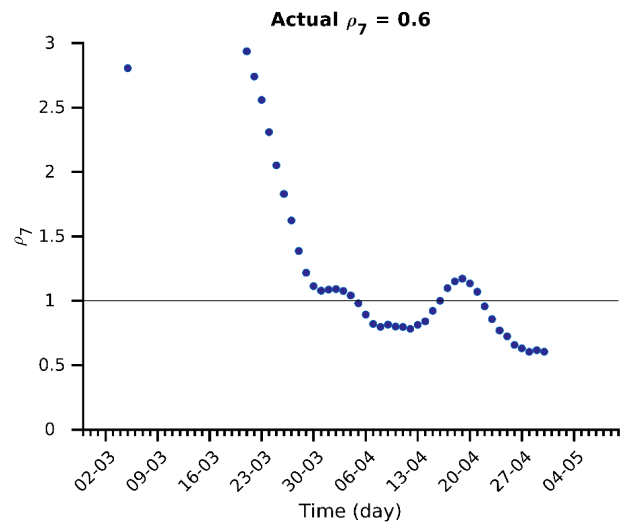
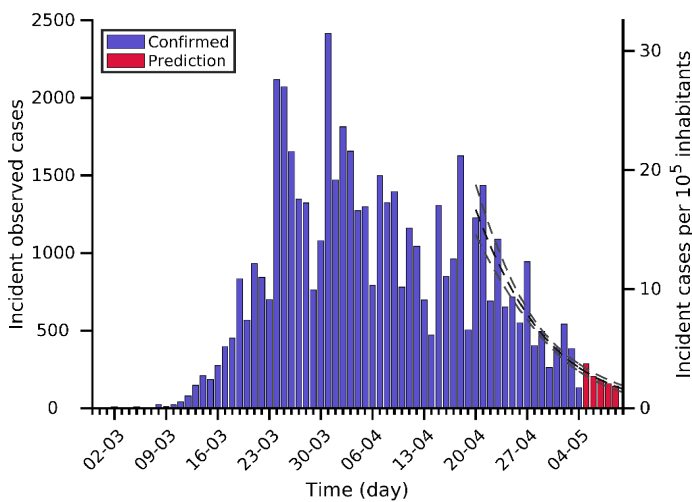
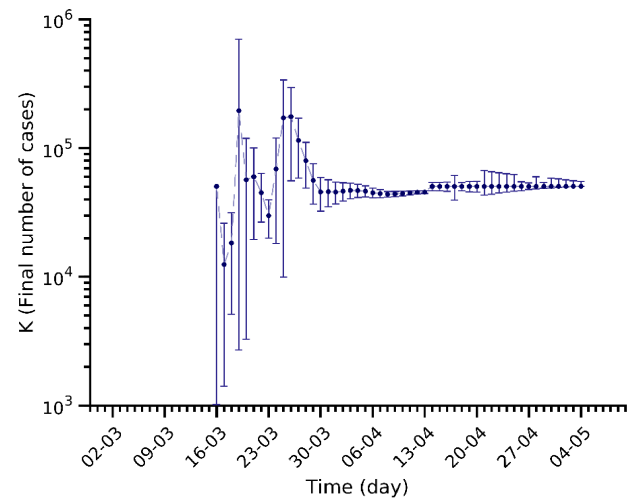
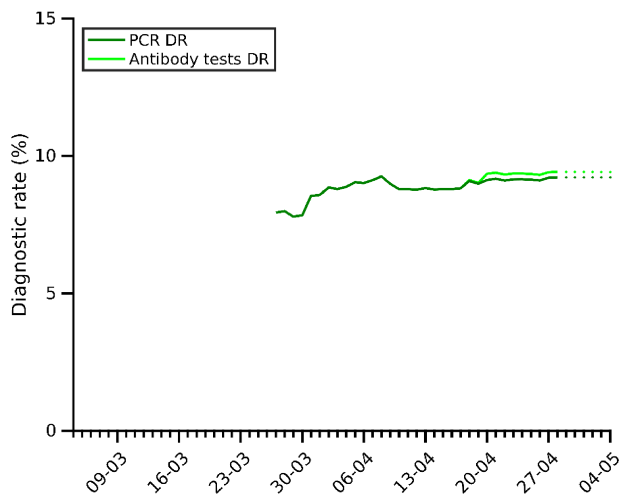
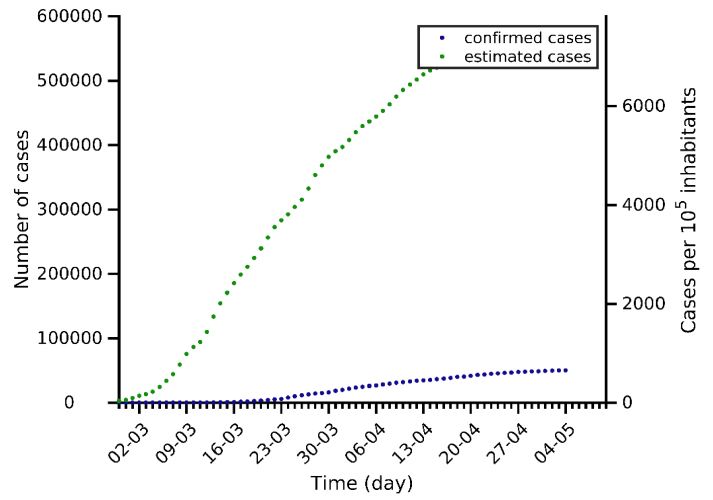
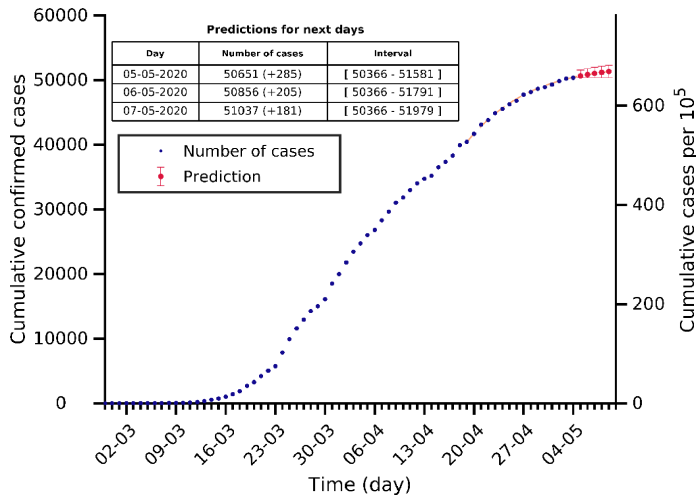
Spain 04-05-2020. Population: 47.0M. Current cumulated incidence: 464/10⁵



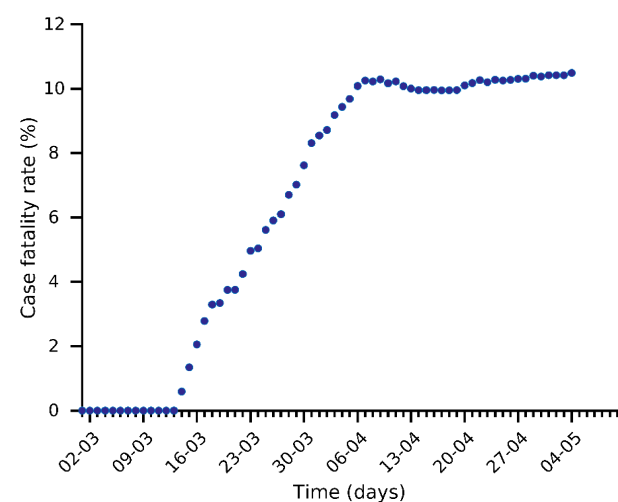
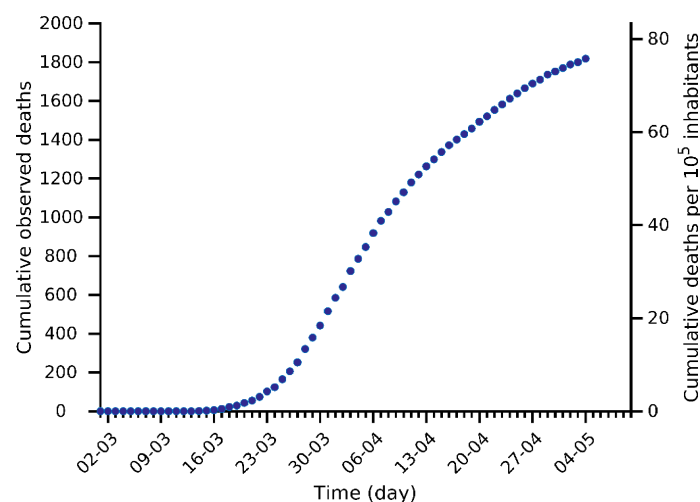
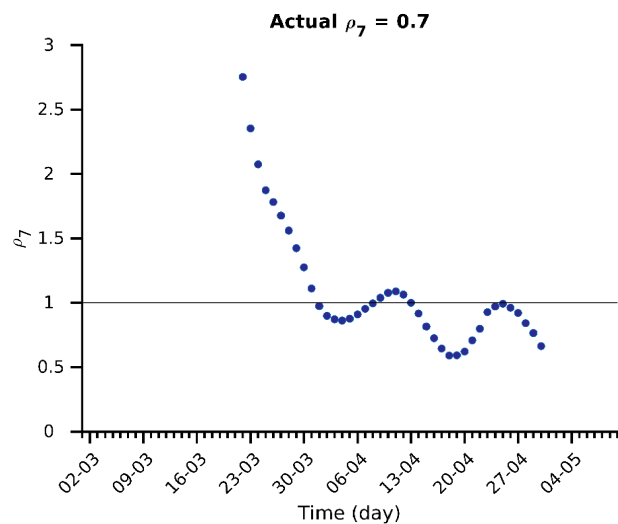
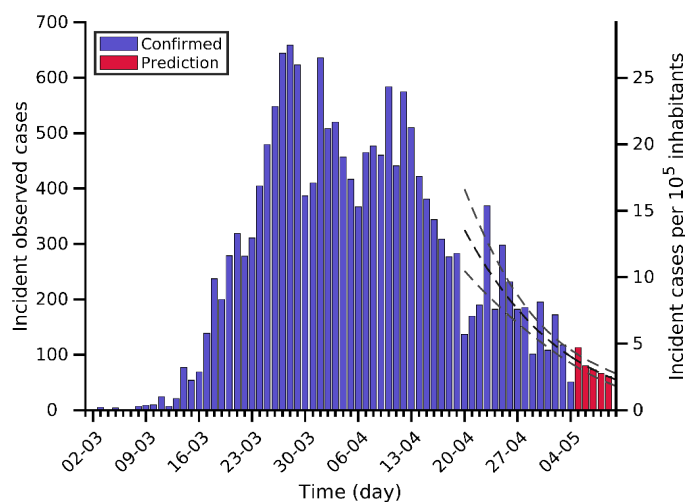
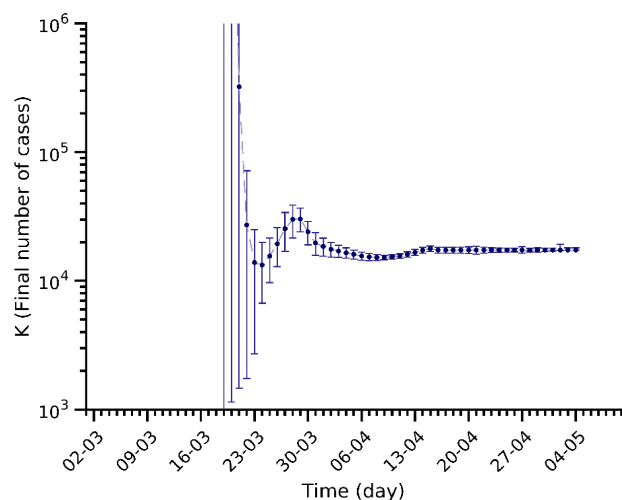
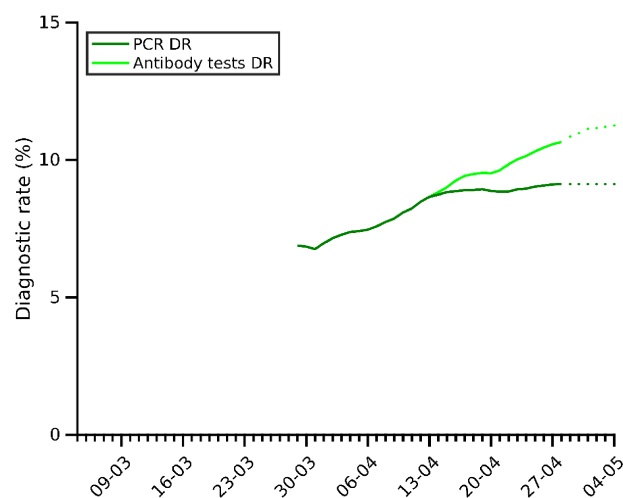
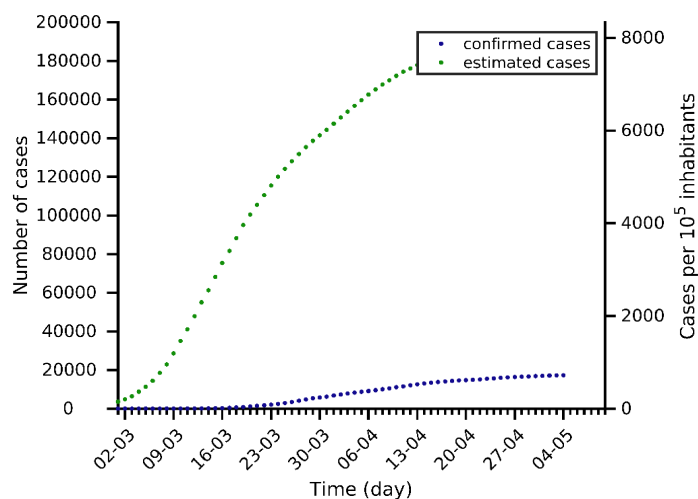
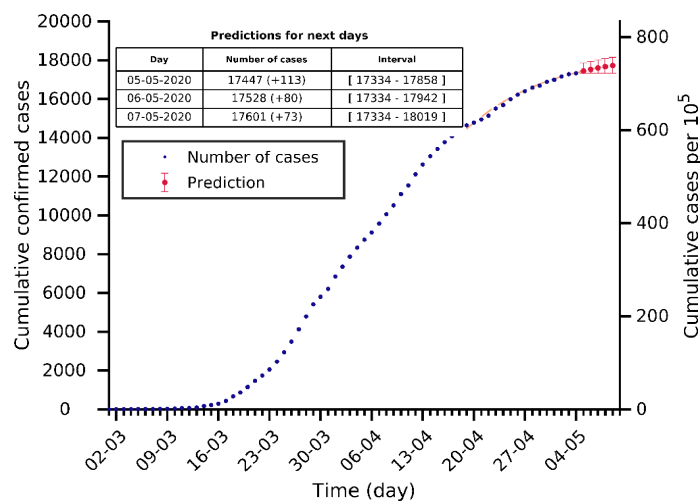
Madrid 04-05-2020. Population: 6.7M. Current cumulated incidence: 936/10⁵



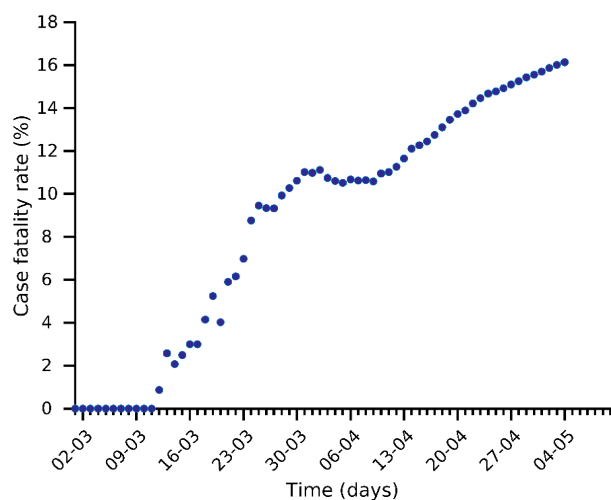
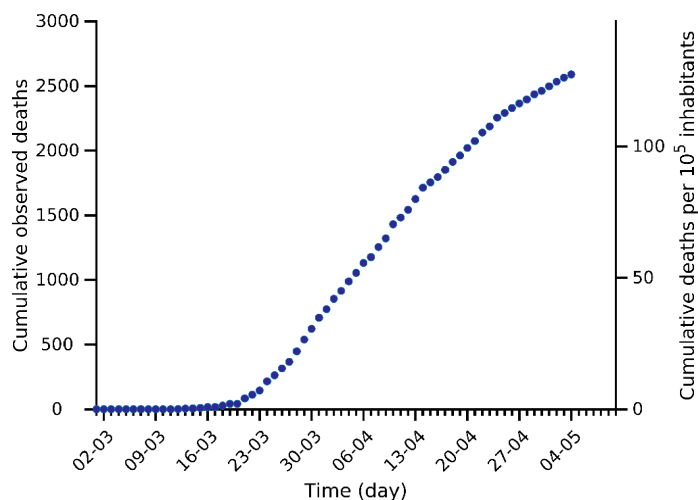
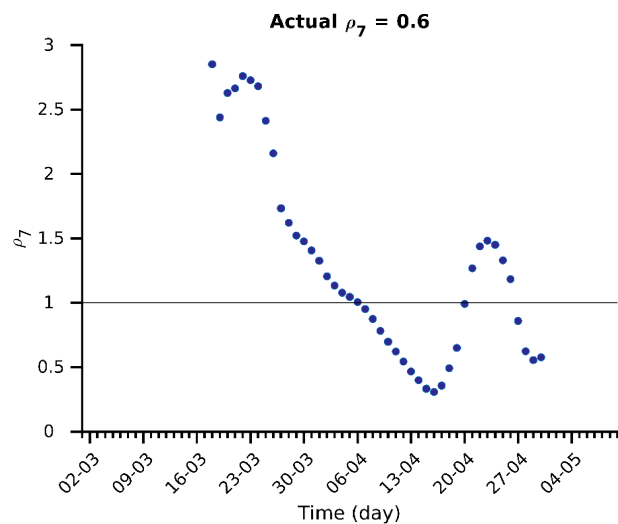
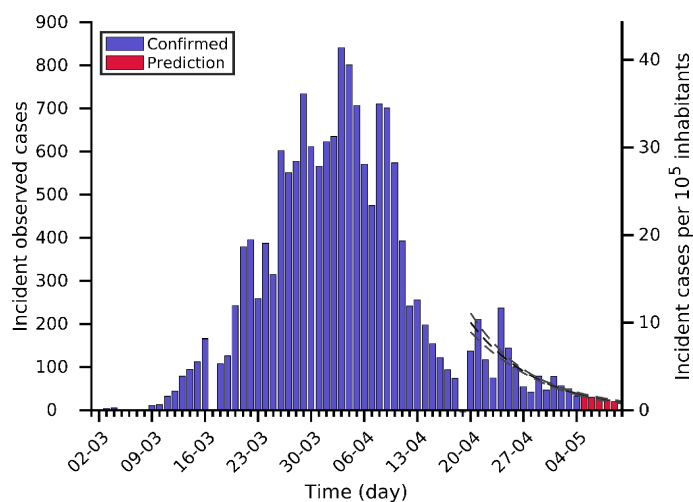
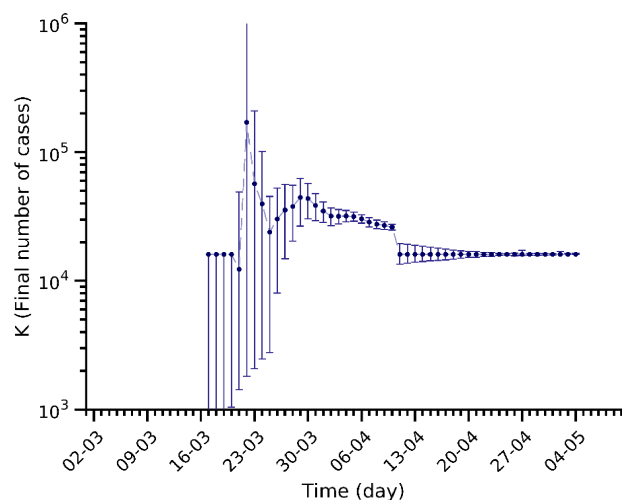
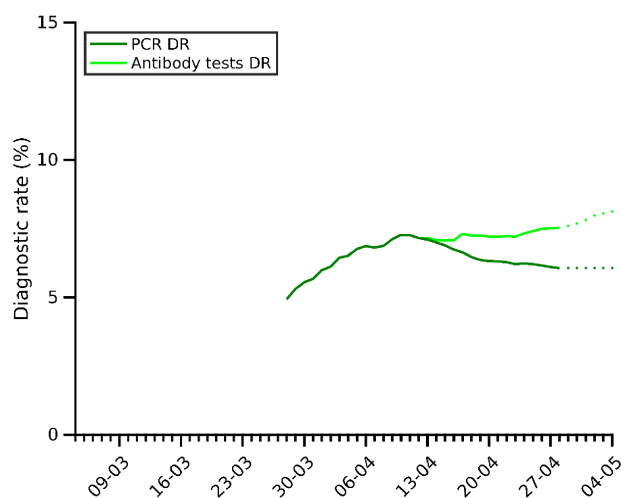
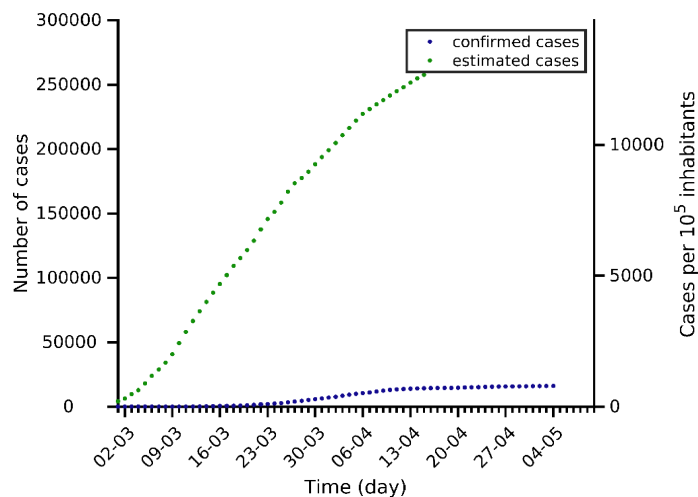
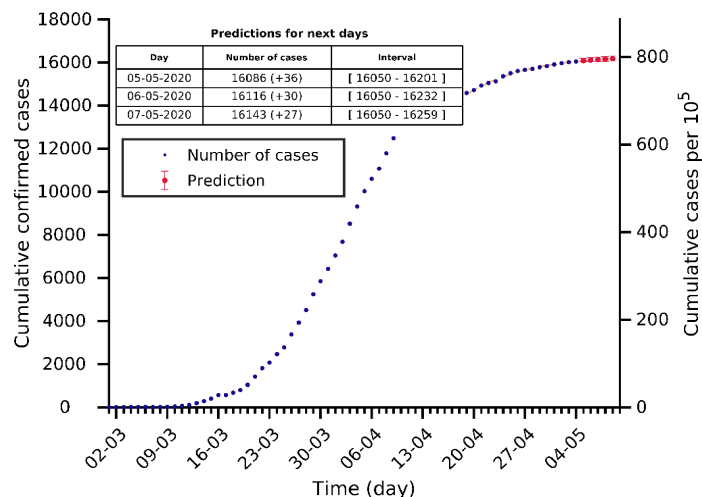
Catalunya 04-05-2020. Population: 7.7M. Current cumulated incidence: 656/10⁵



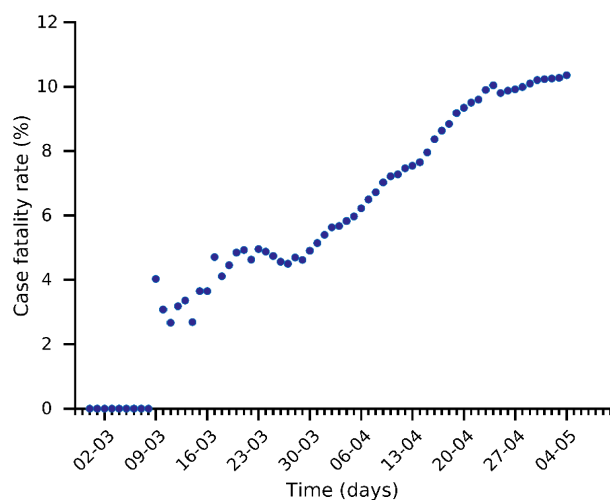
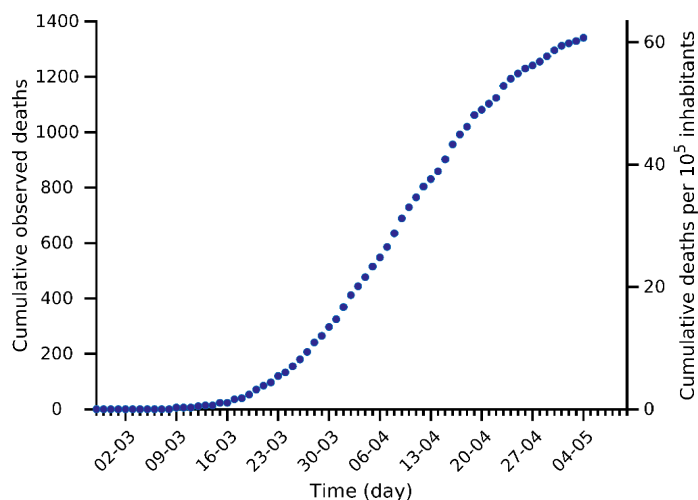
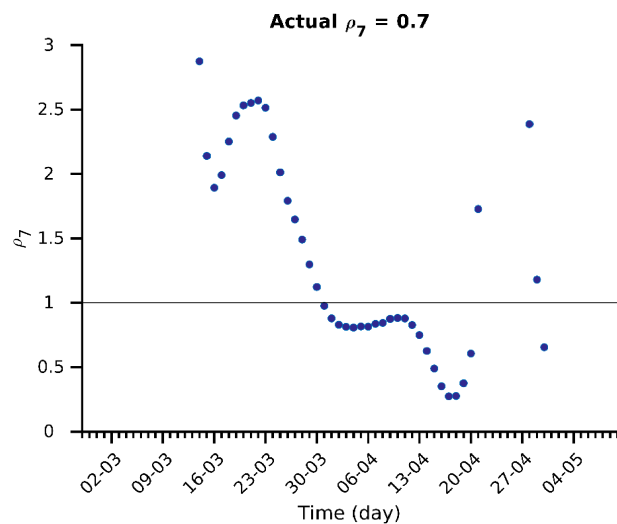
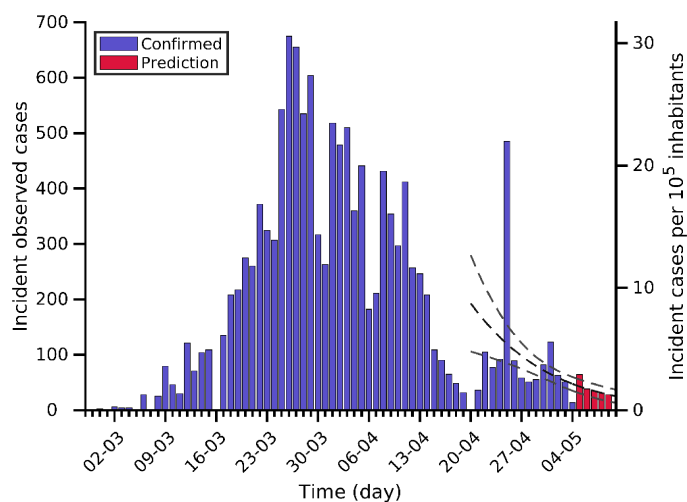
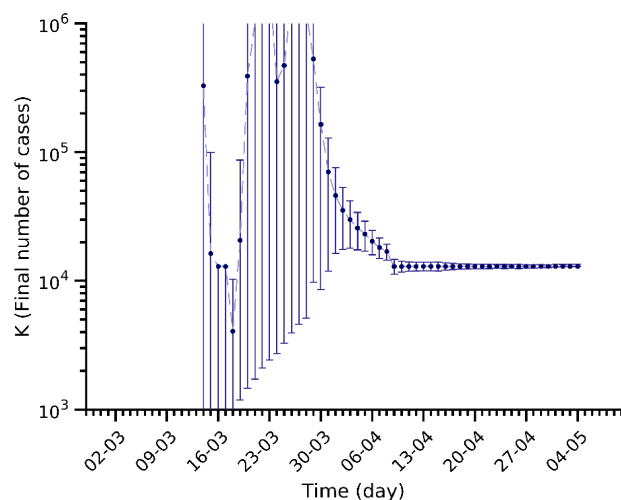
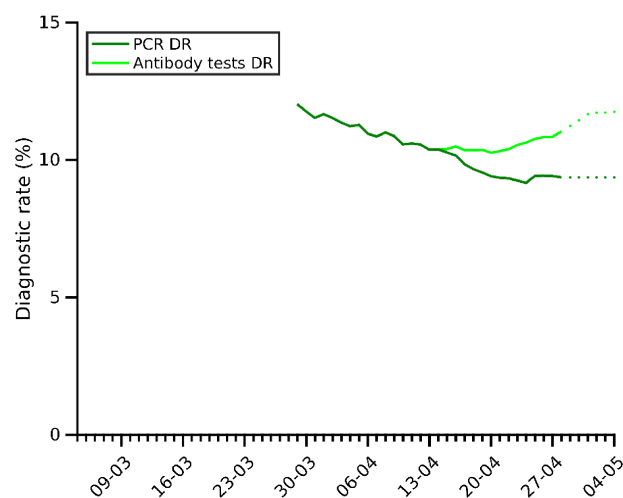
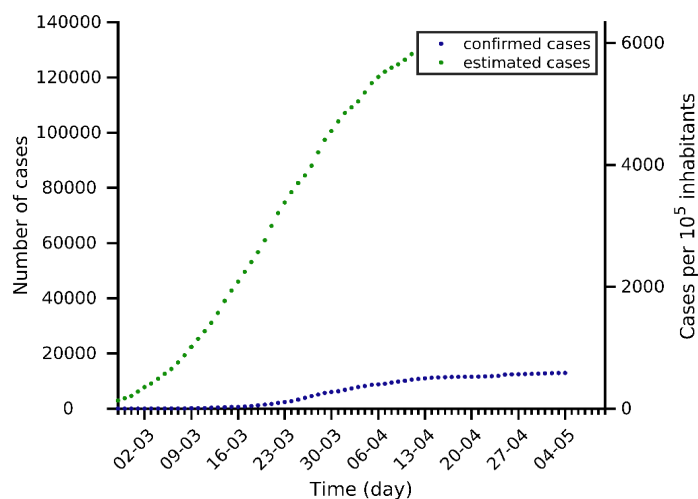
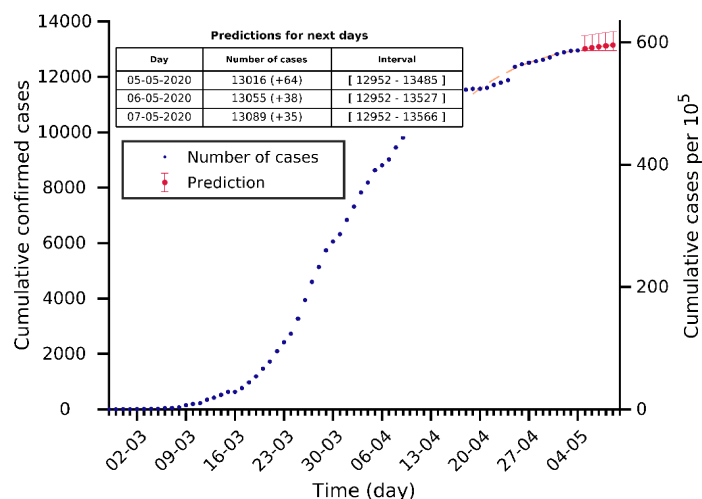
Castilla Leon 04-05-2020. Population: 2.4M. Current cumulated incidence: 722/10⁵



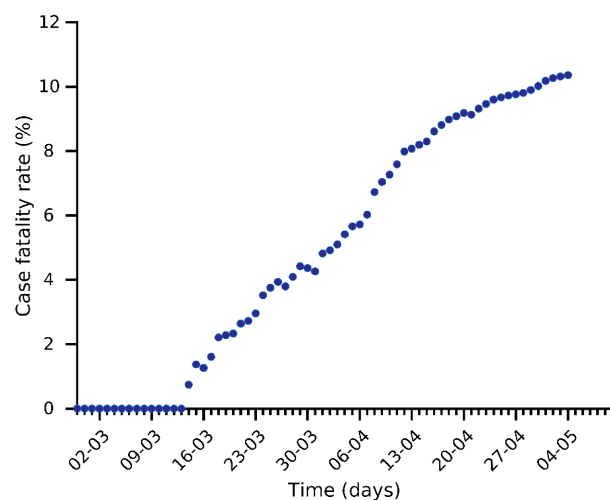
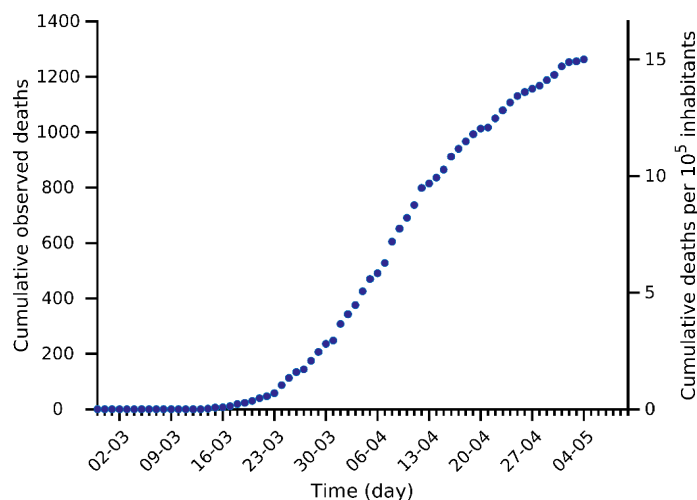
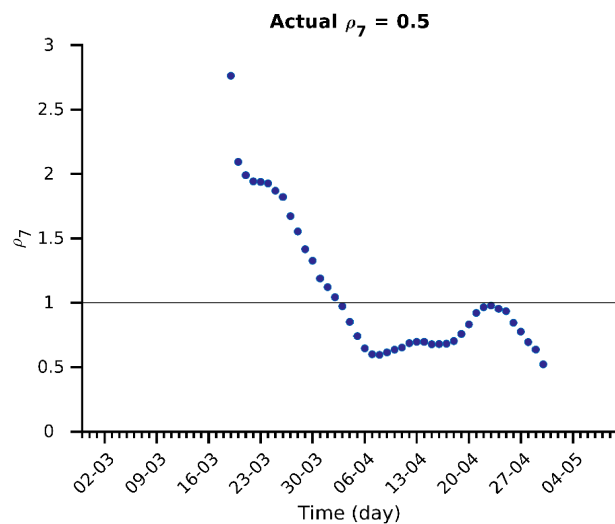
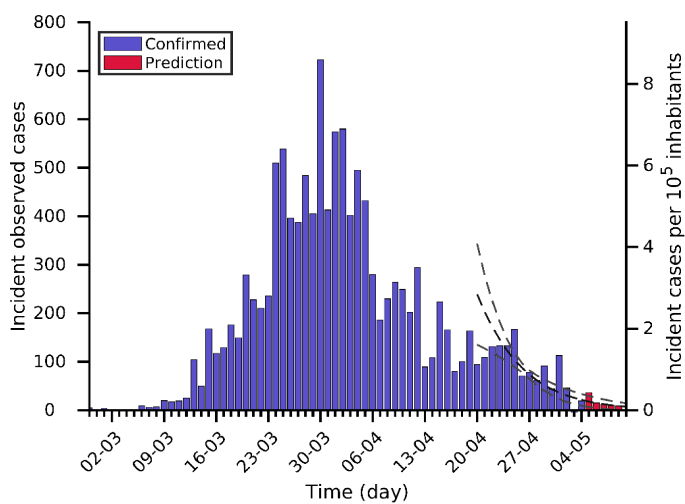
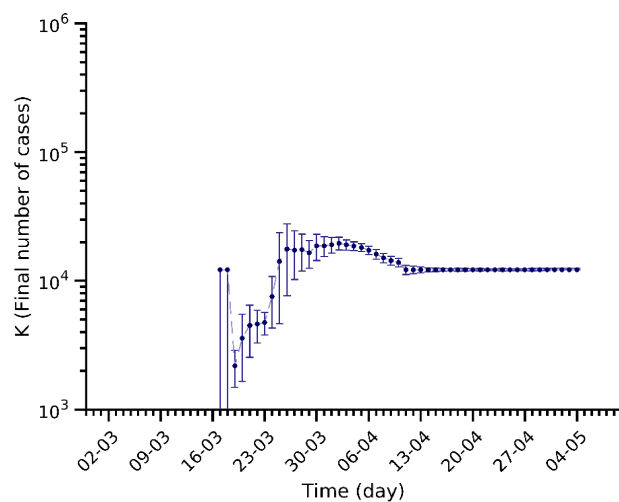
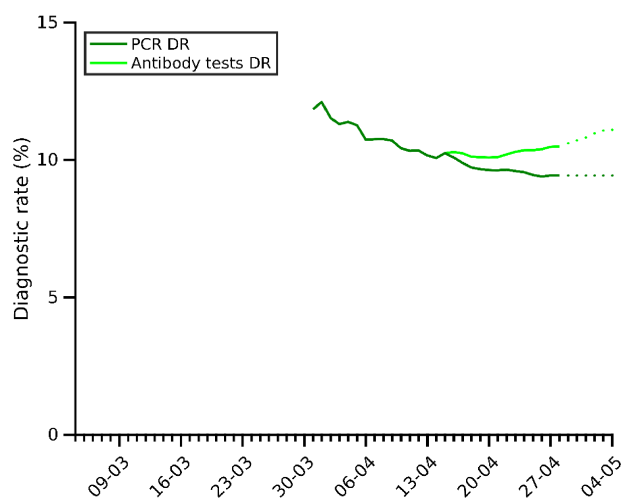
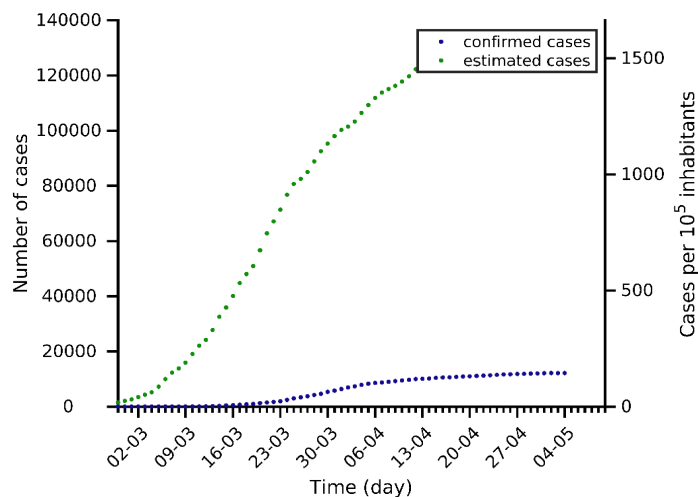
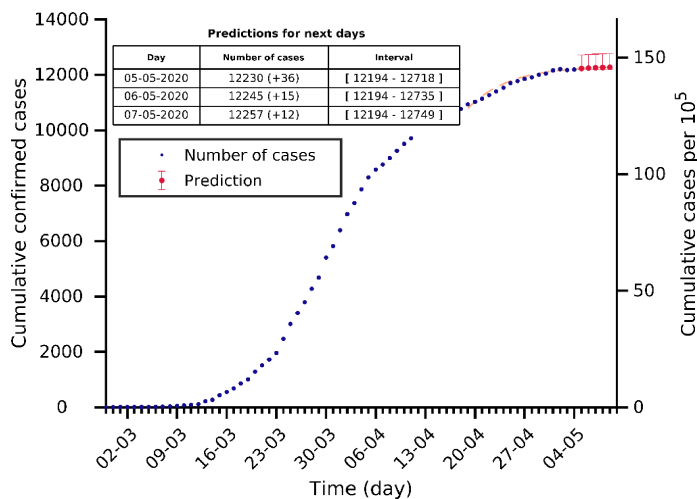
Castilla-La Mancha 04-05-2020. Population: 2.0M. Current cumulated incidence: 79



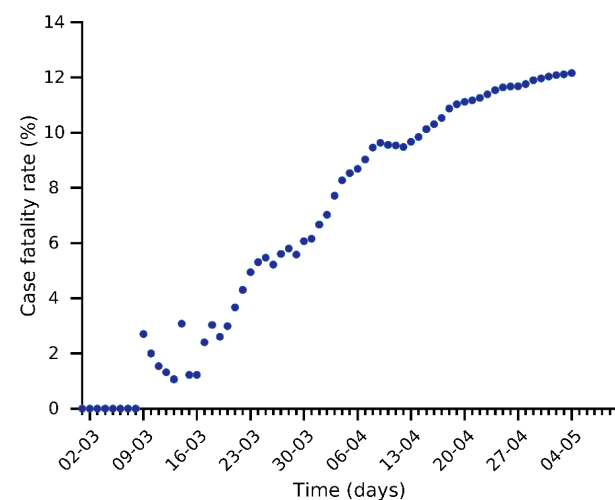
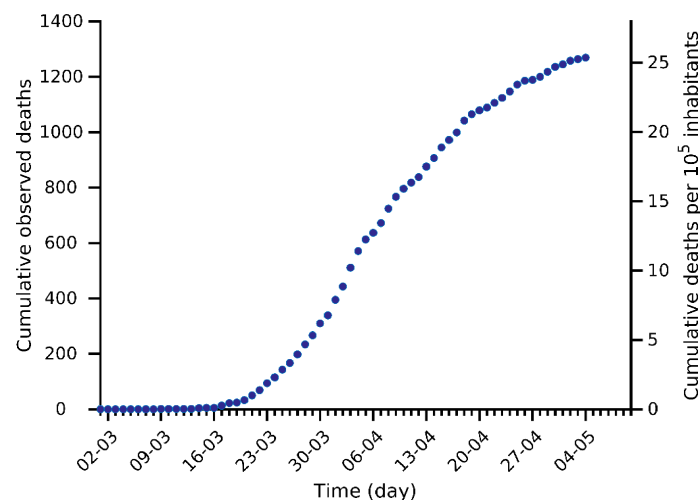
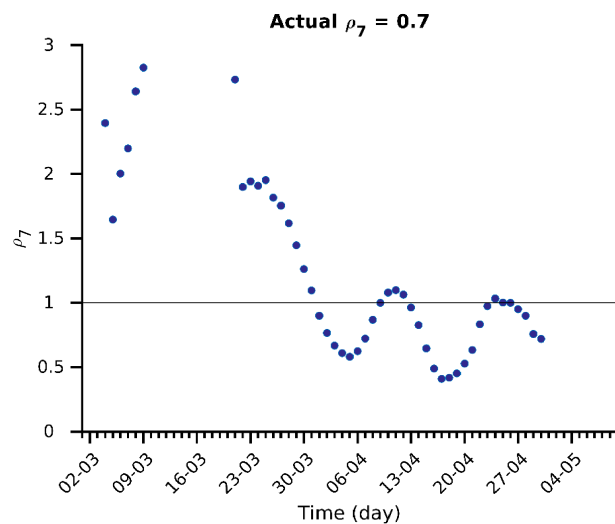
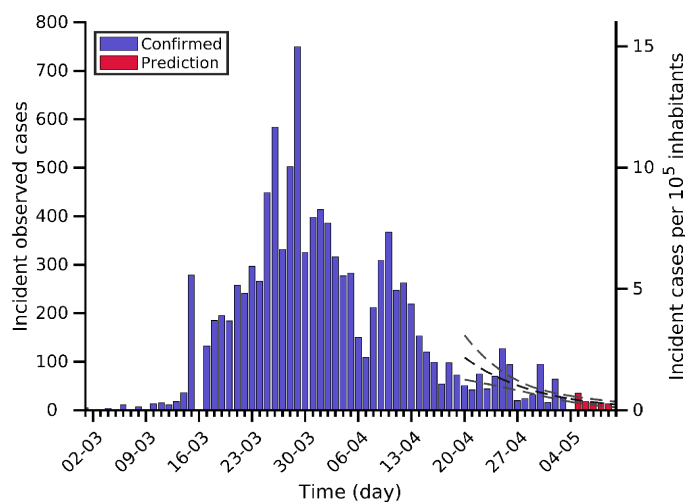
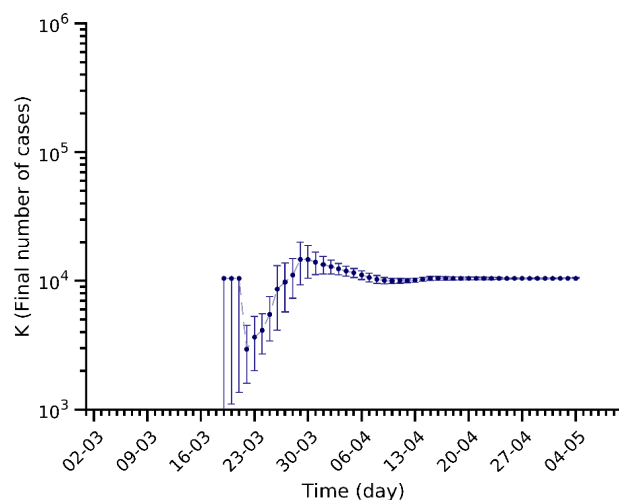
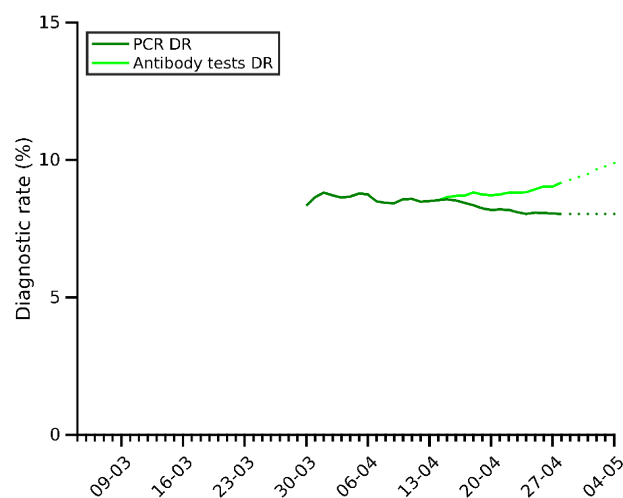
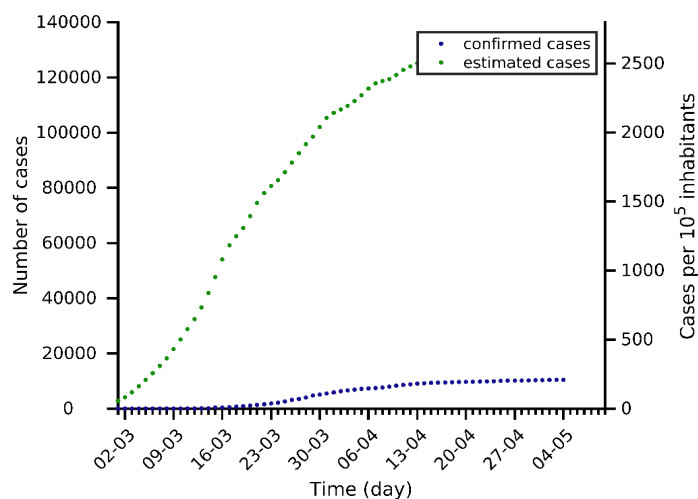
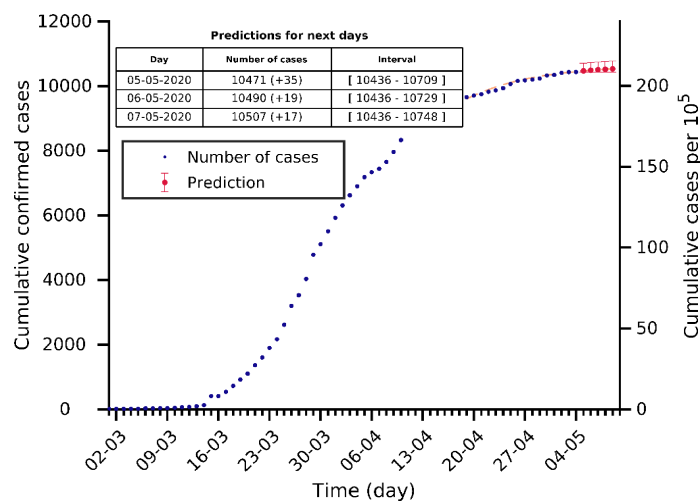
Euskadi 04-05-2020. Population: 2.2M. Current cumulated incidence: 587/10⁵



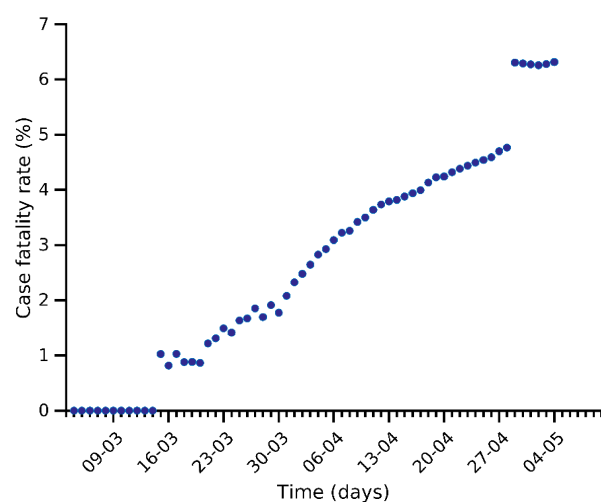
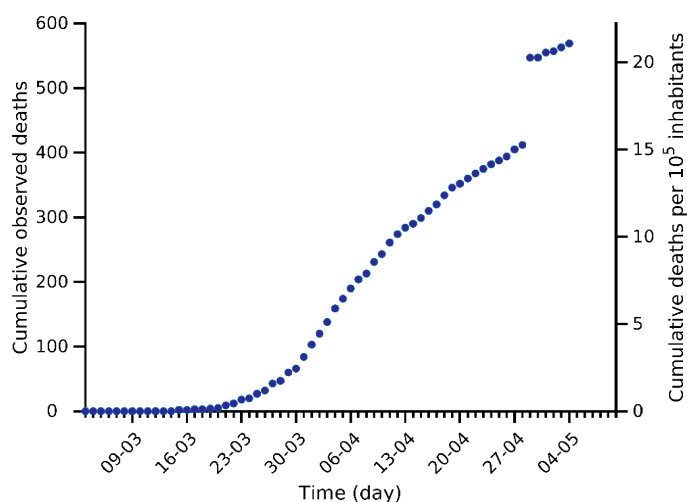
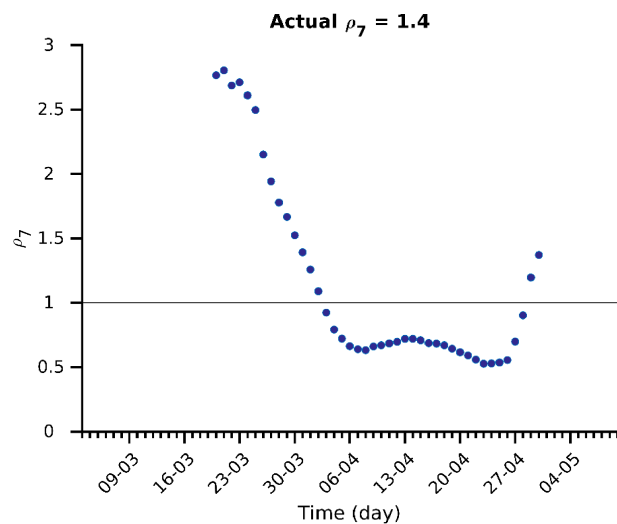
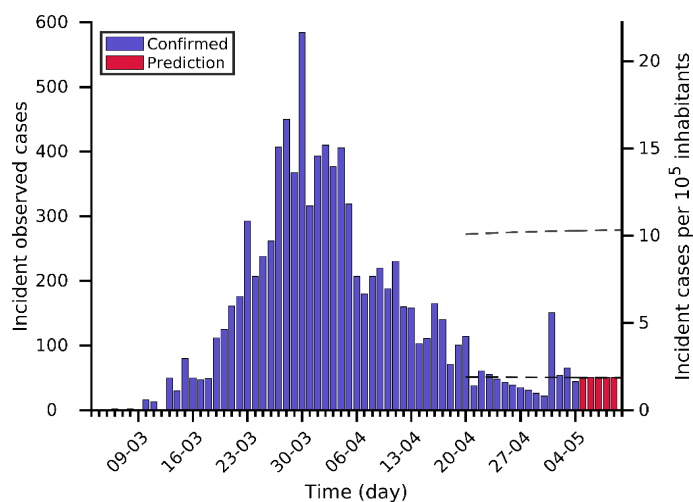
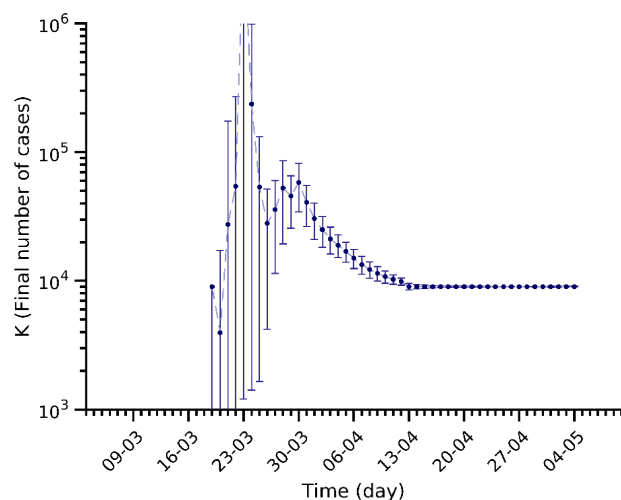
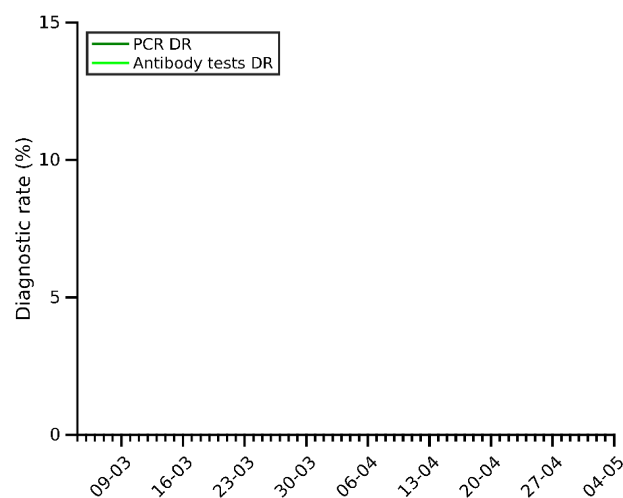
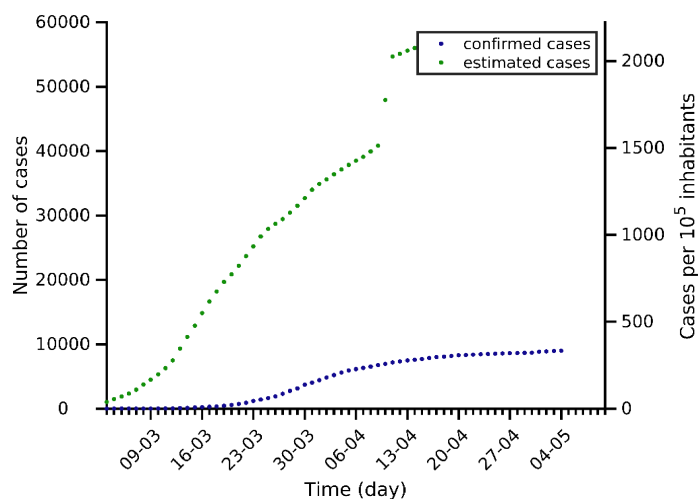
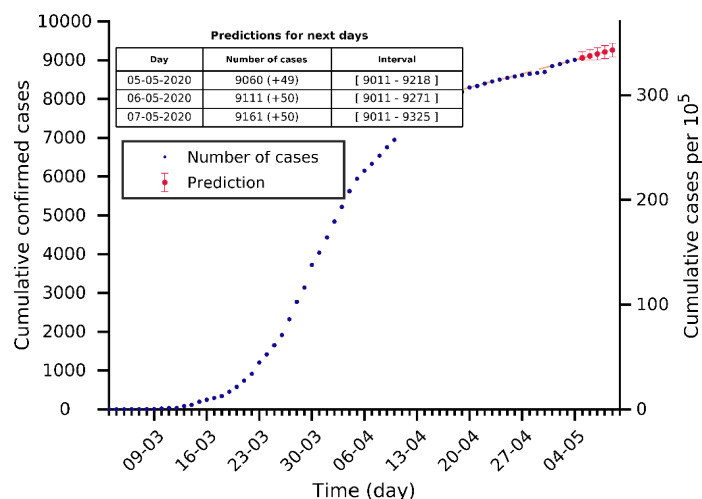
Andalucia 04-05-2020. Population: 8.4M. Current cumulated incidence: 145/10⁵



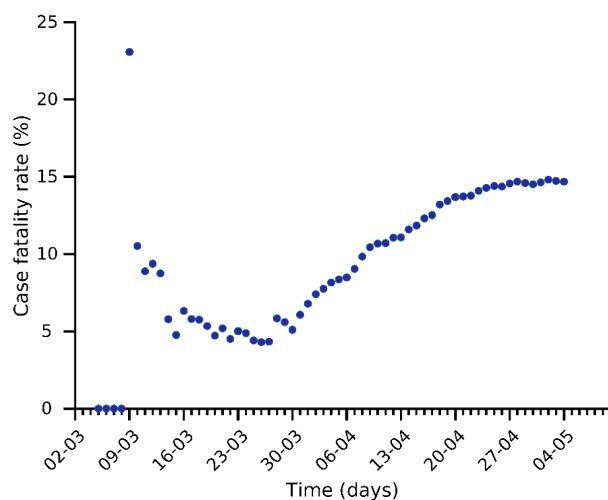
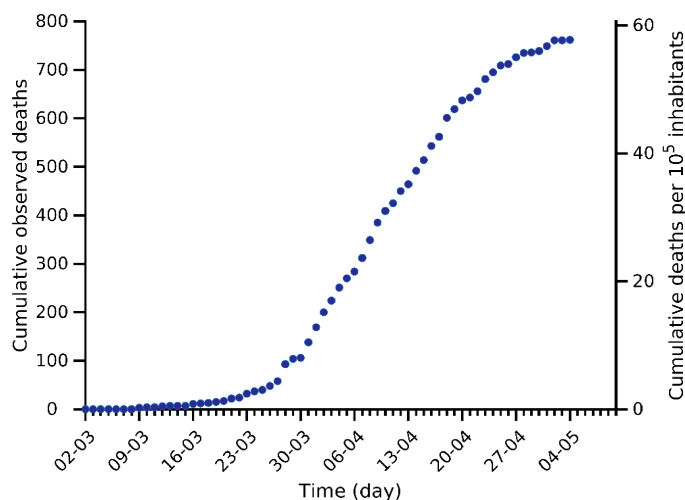
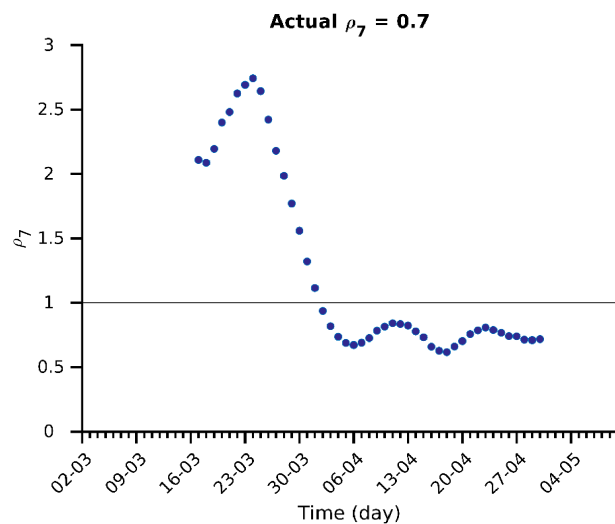
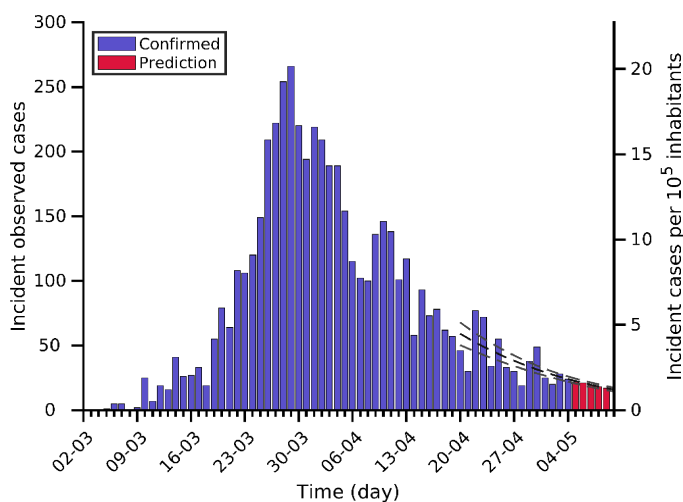
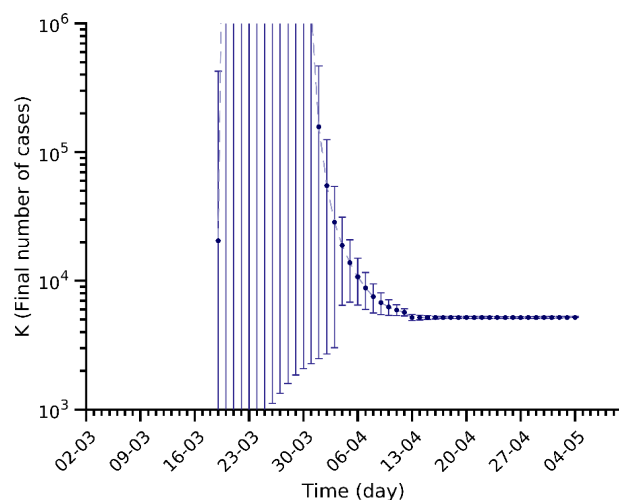
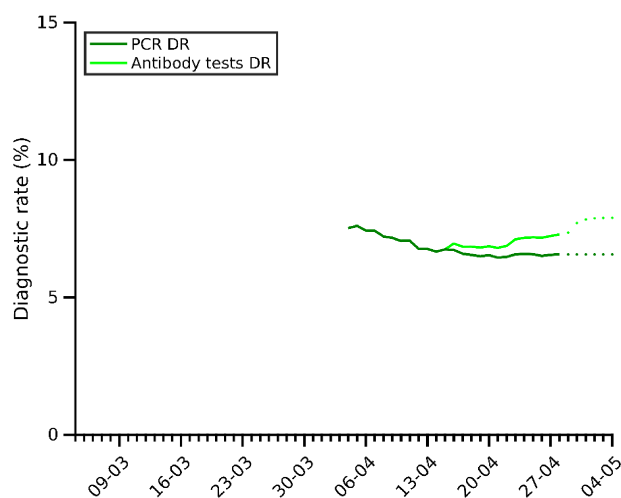
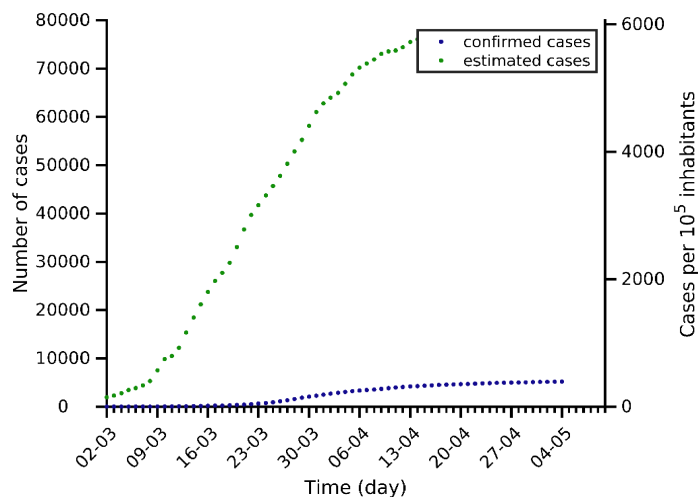
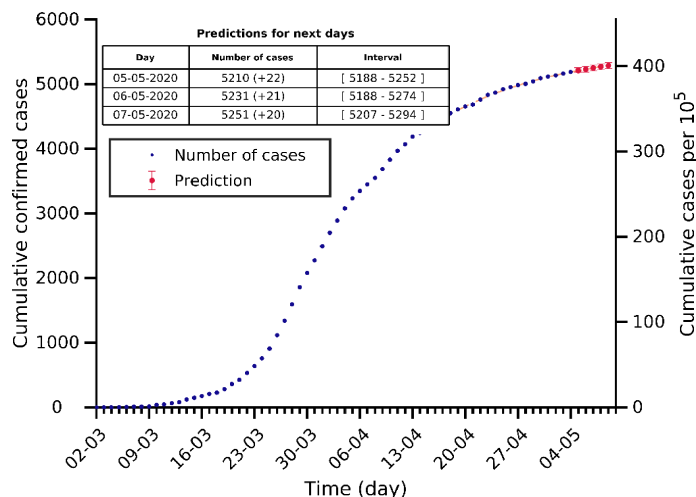
C Valenciana 04-05-2020. Population: 5.0M. Current cumulated incidence: 209/10⁵



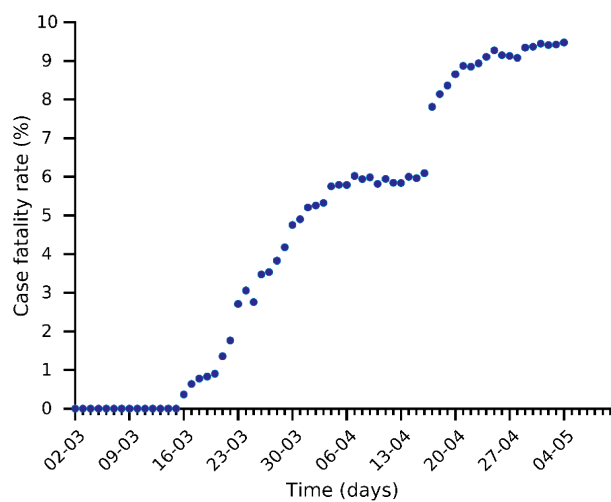
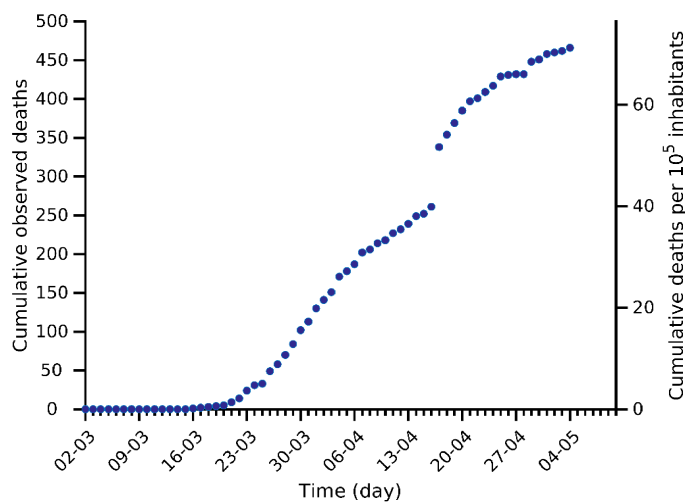
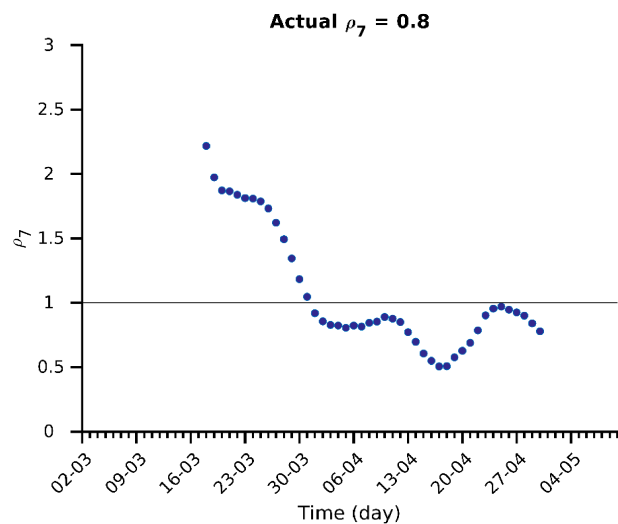
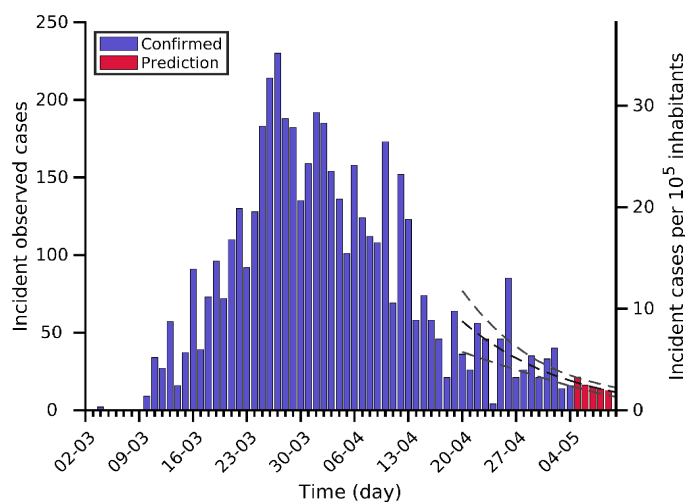
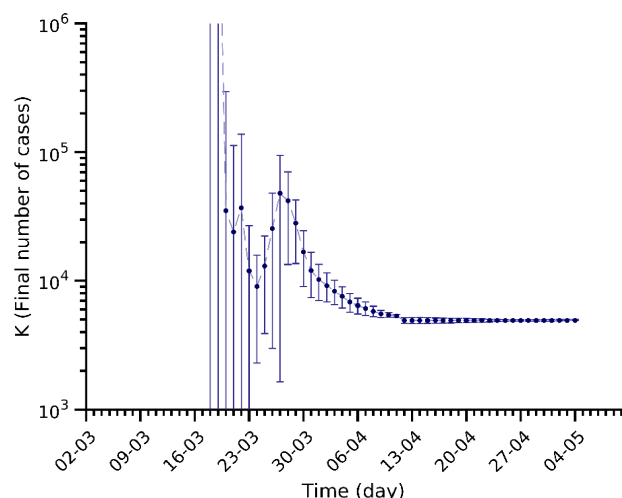
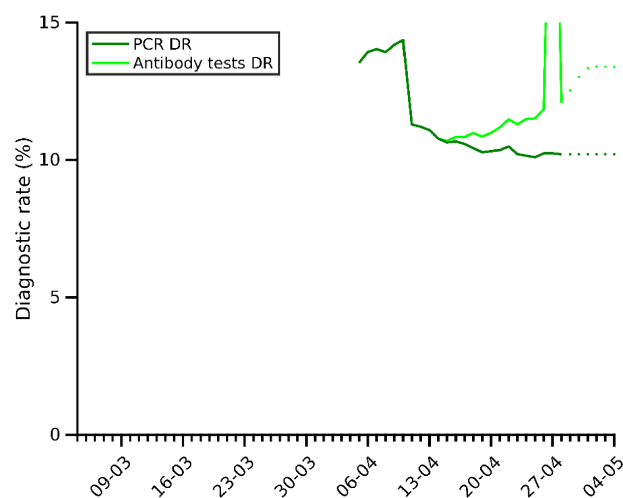
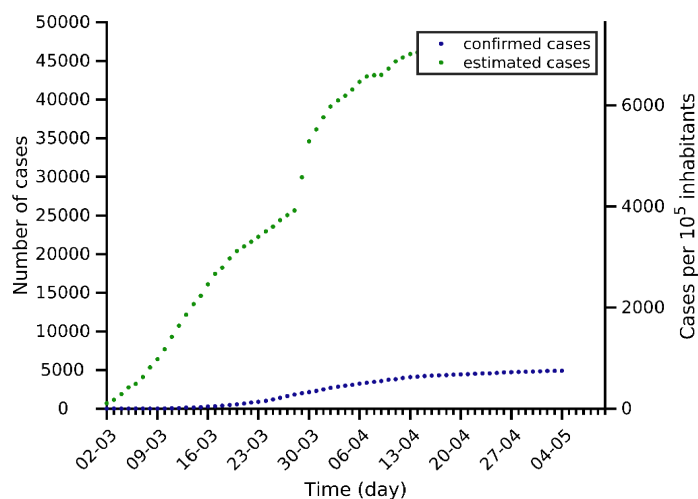
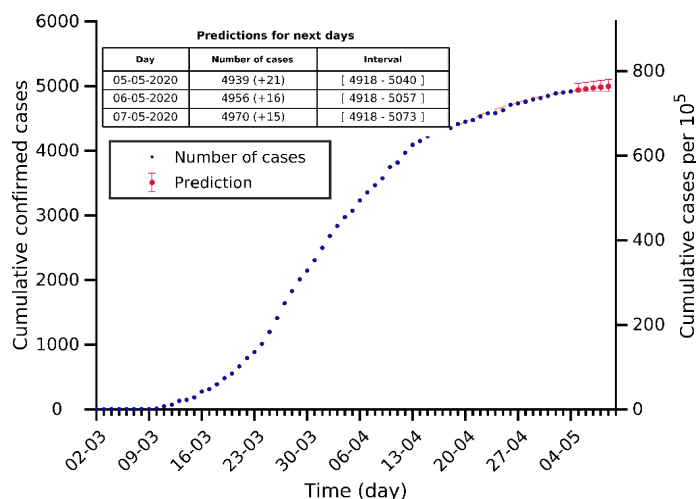
Galicia 04-05-2020. Population: 2.7M. Current cumulated incidence: 334/10⁵



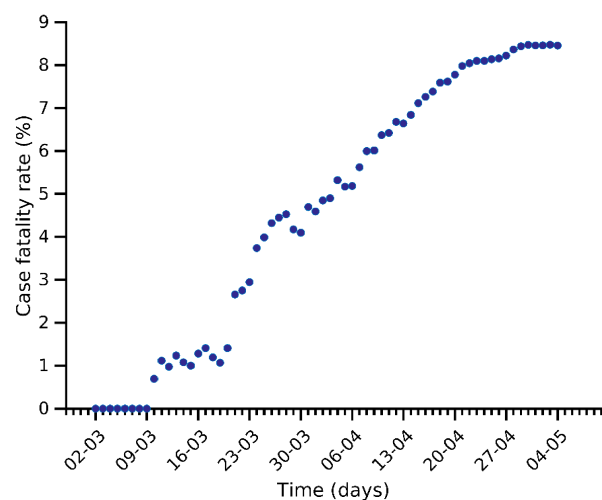
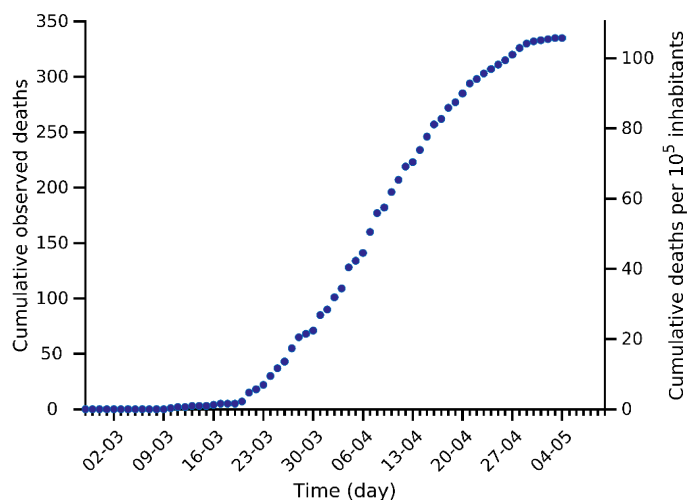
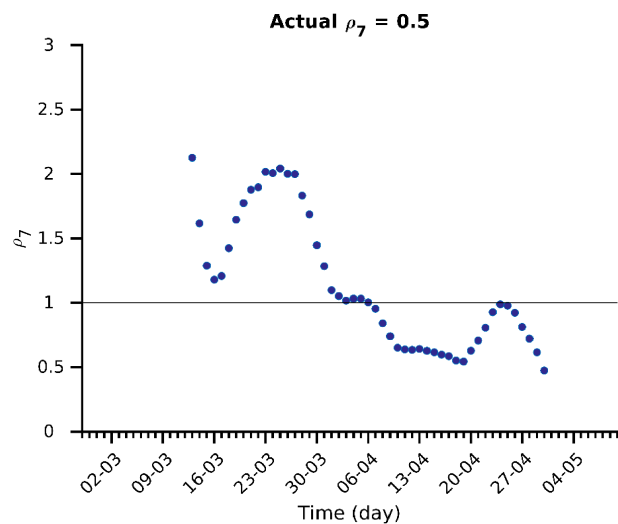
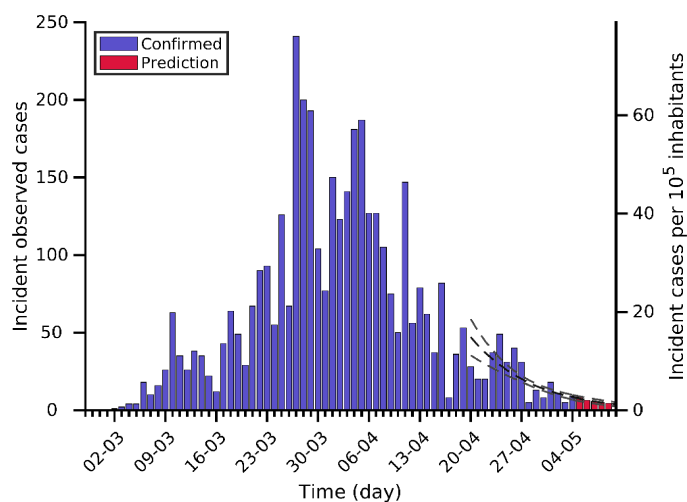
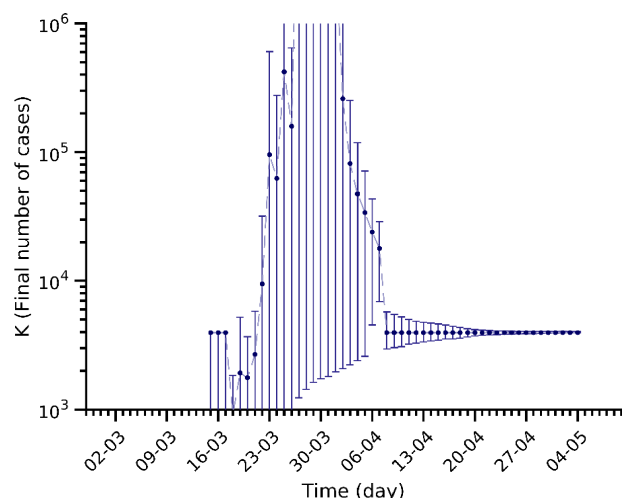
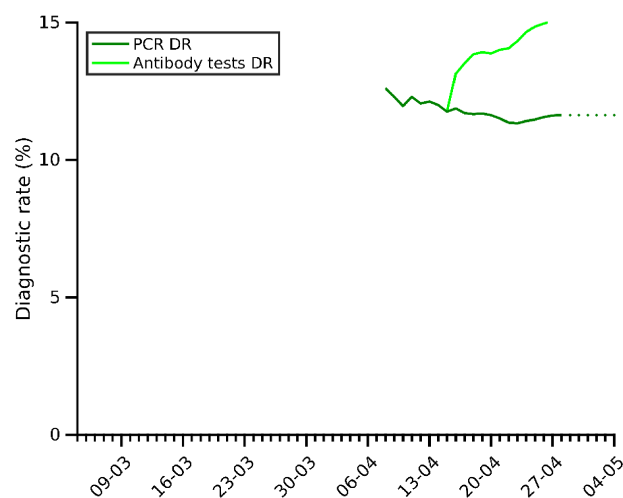
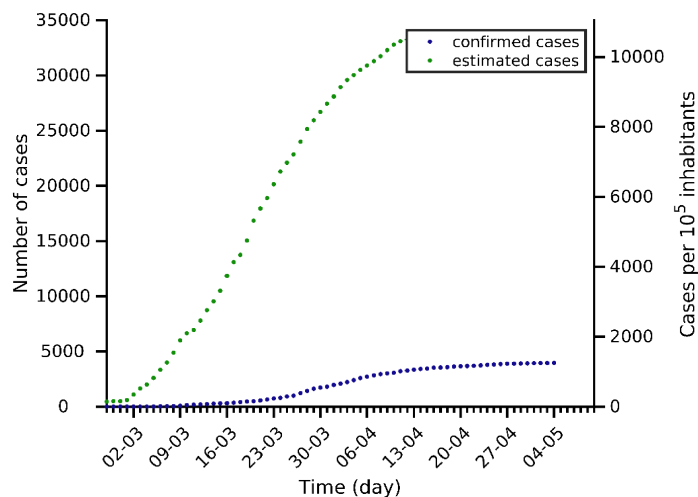
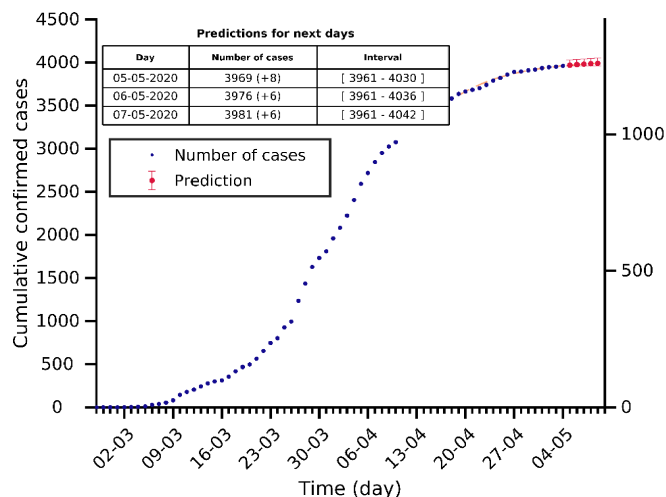
Aragon 04-05-2020. Population: 1.3M. Current cumulated incidence: 393/10⁵



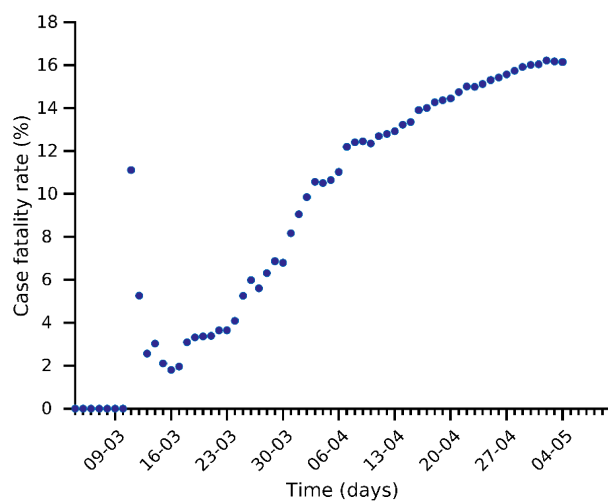
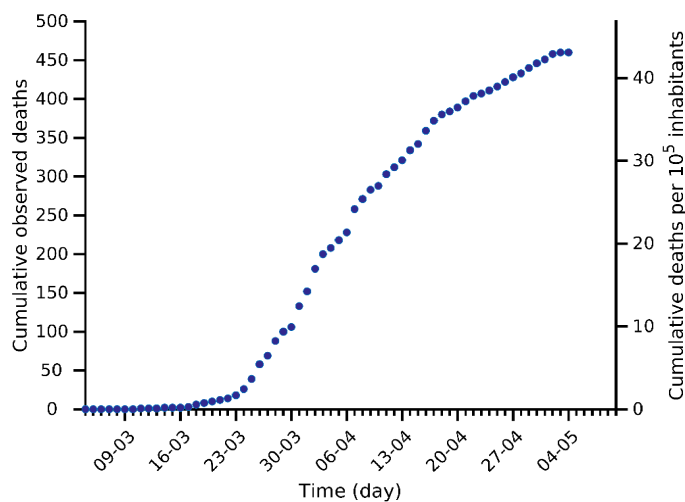
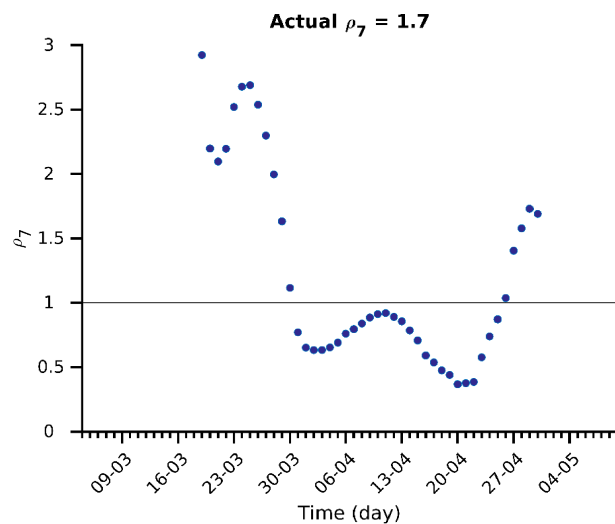
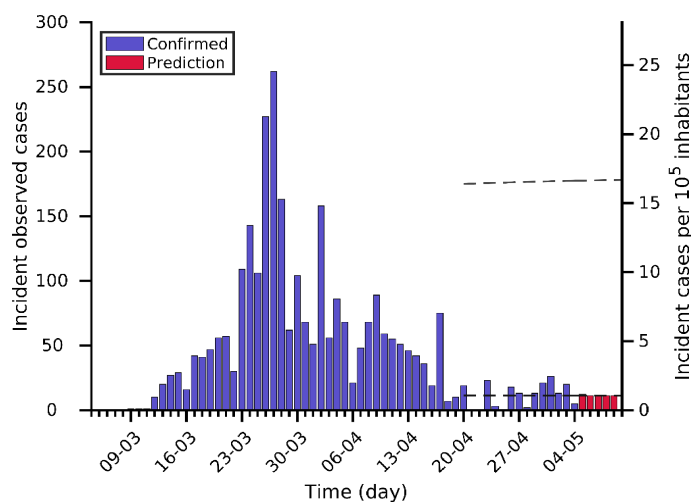
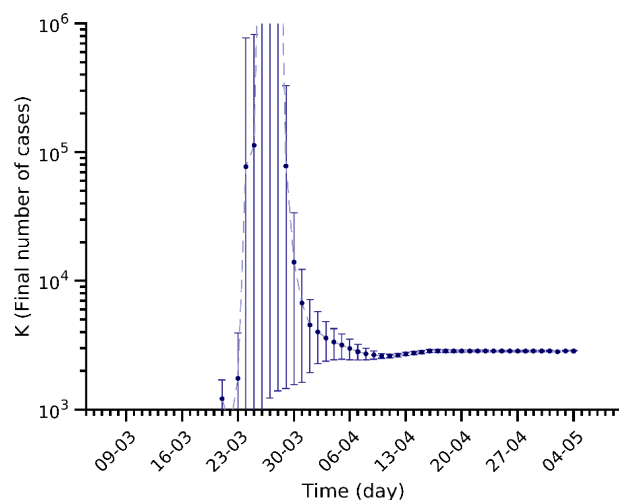
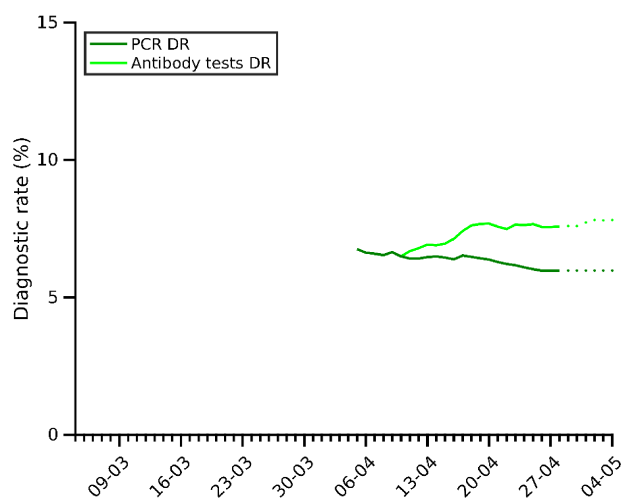
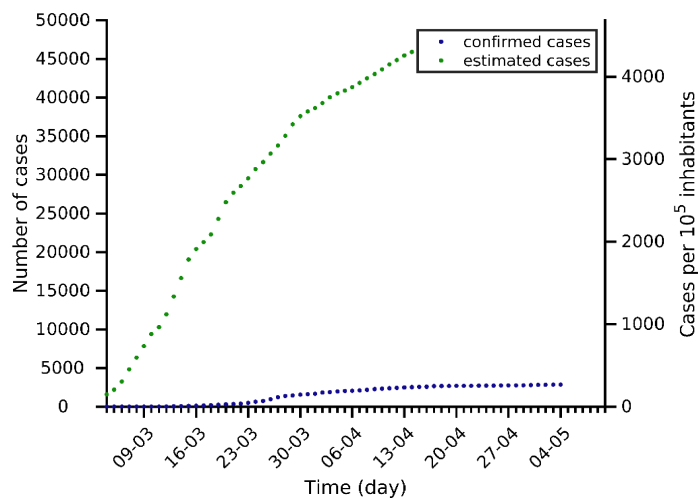
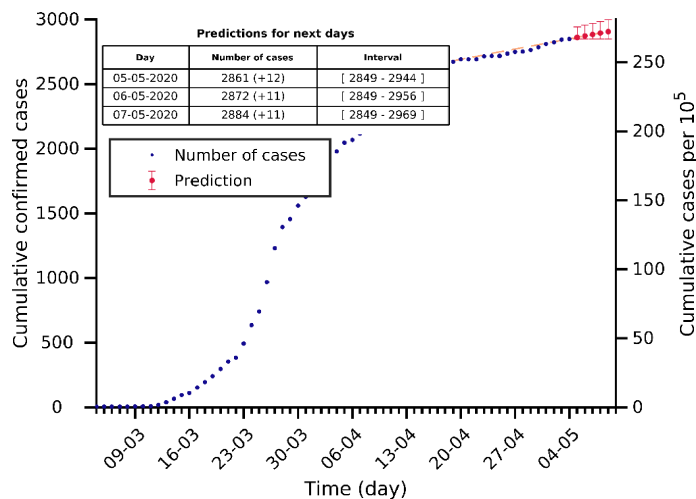
Navarra 04-05-2020. Population: 0.7M. Current cumulated incidence: 752/10⁵



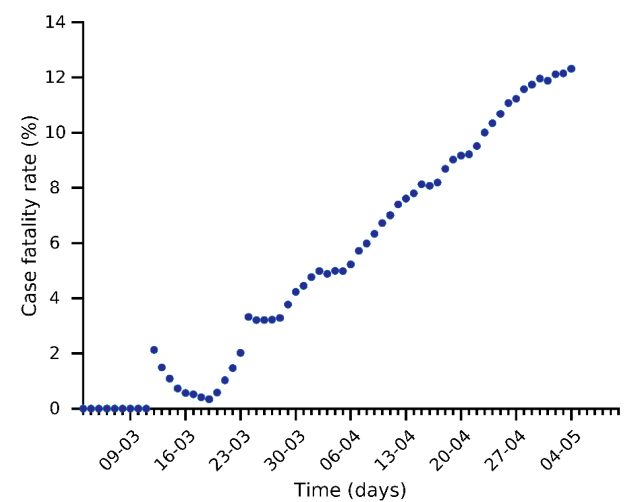
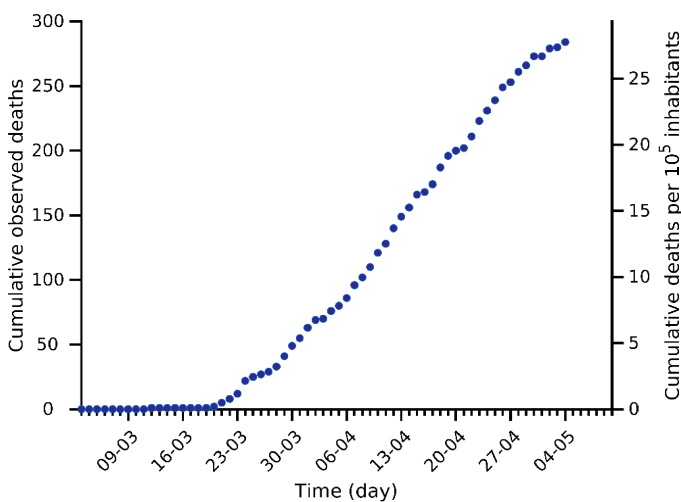
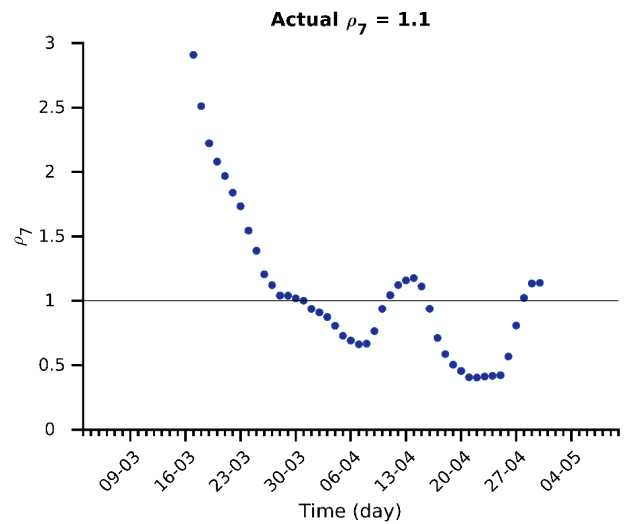
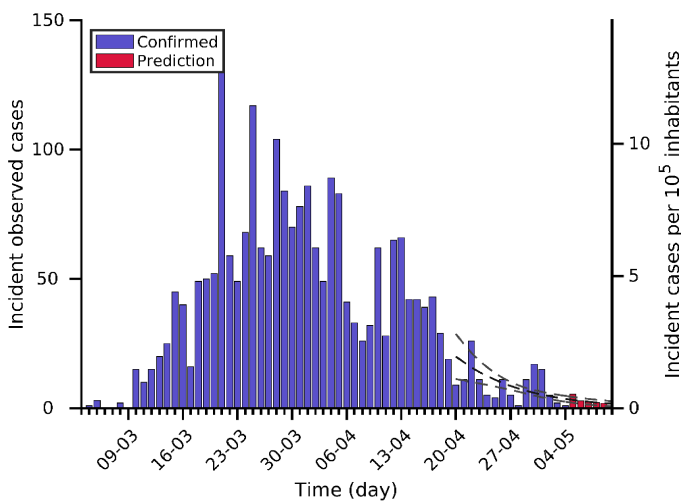
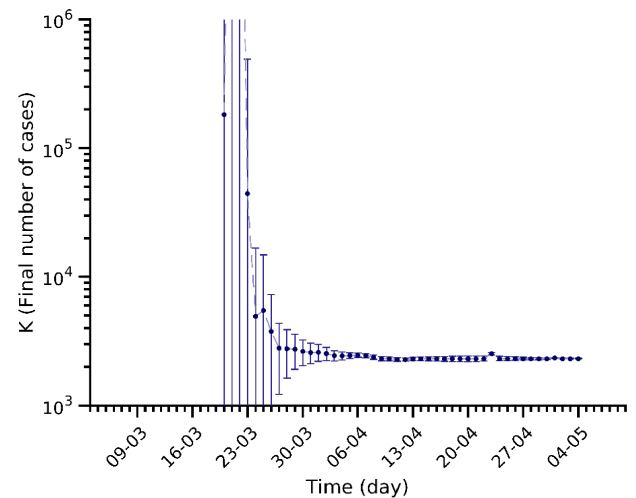
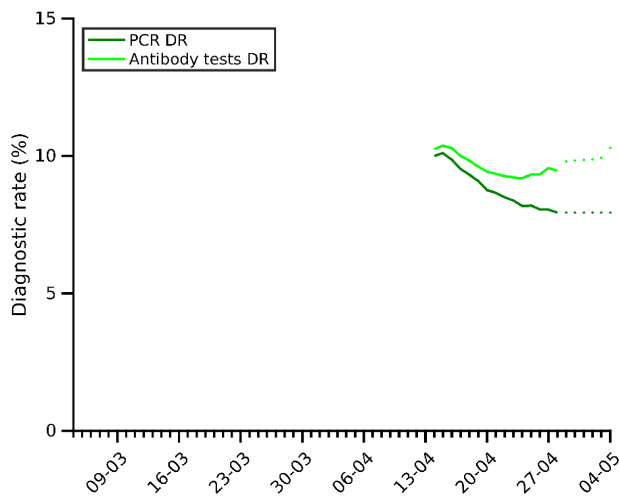
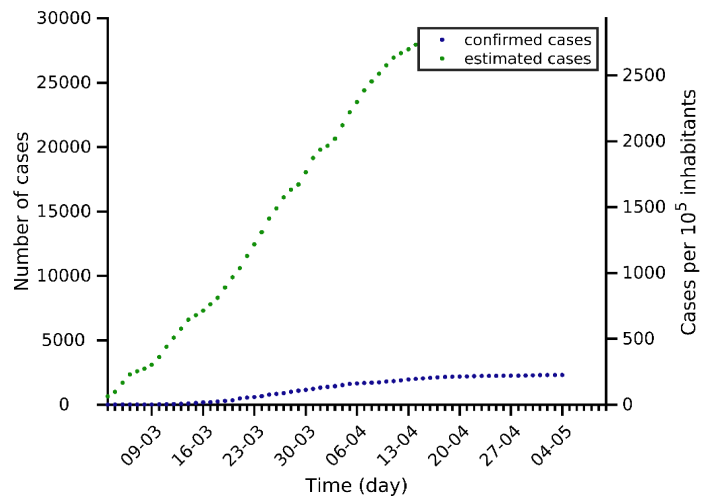
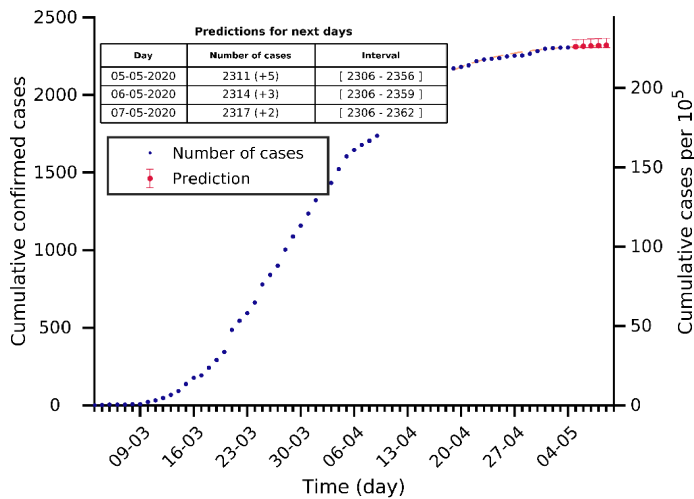
La Rioja 04-05-2020. Population: 0.3M. Current cumulated incidence: 1250/10⁵



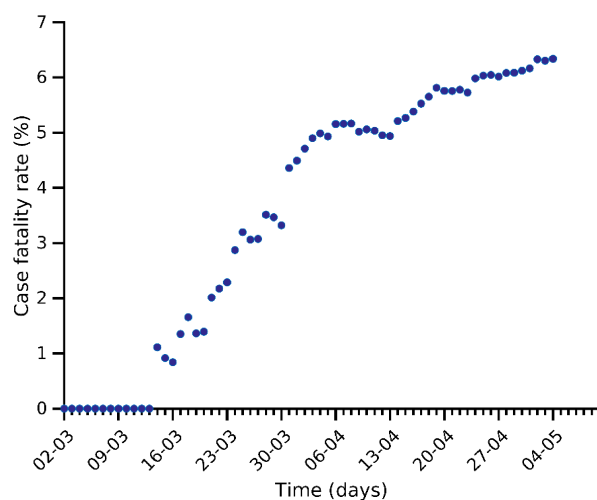
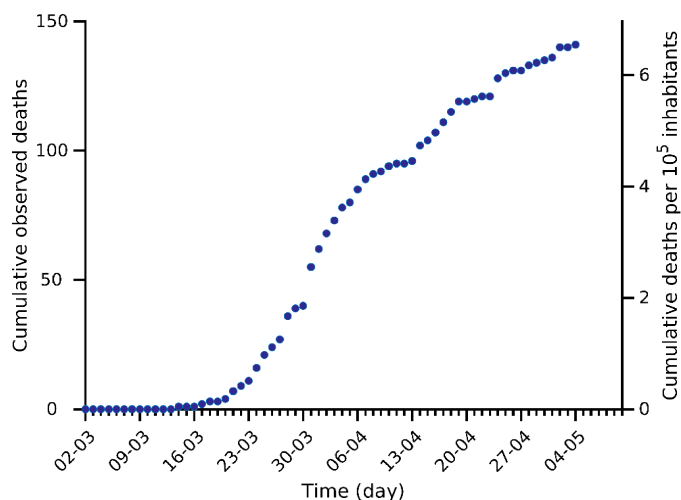
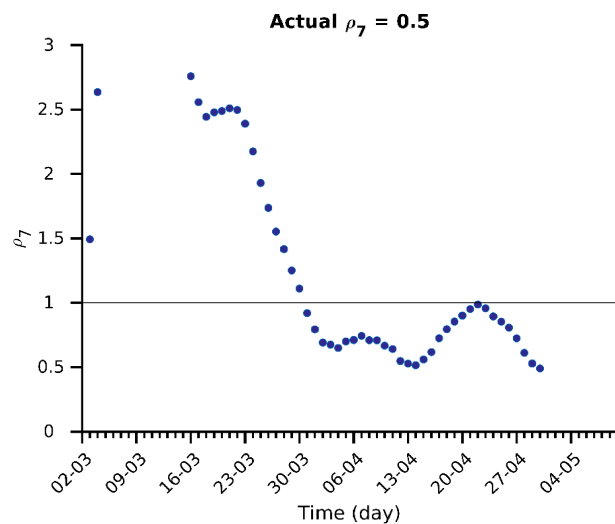
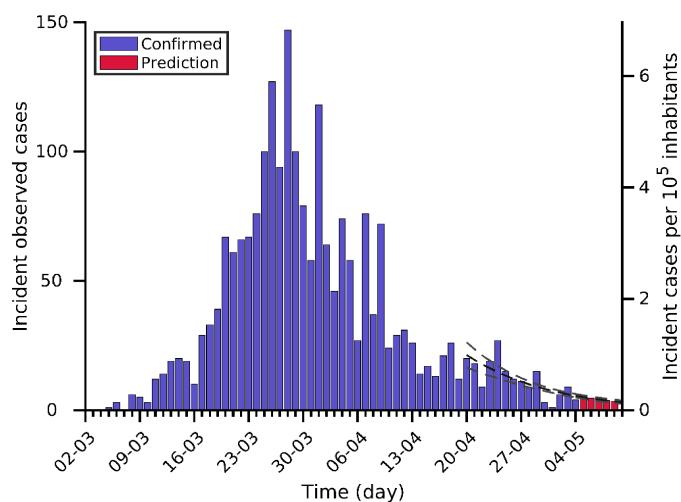
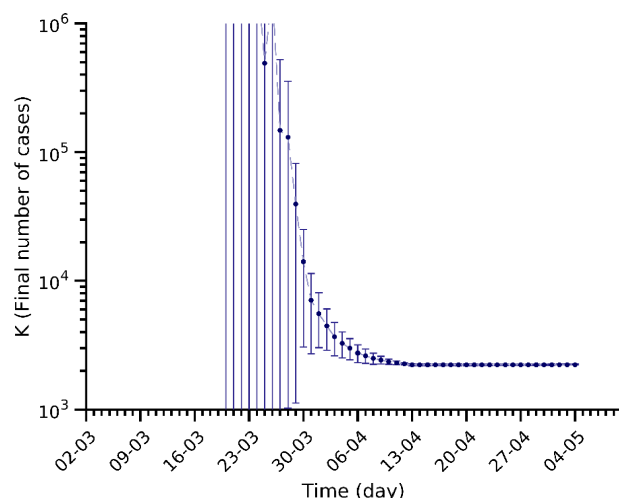
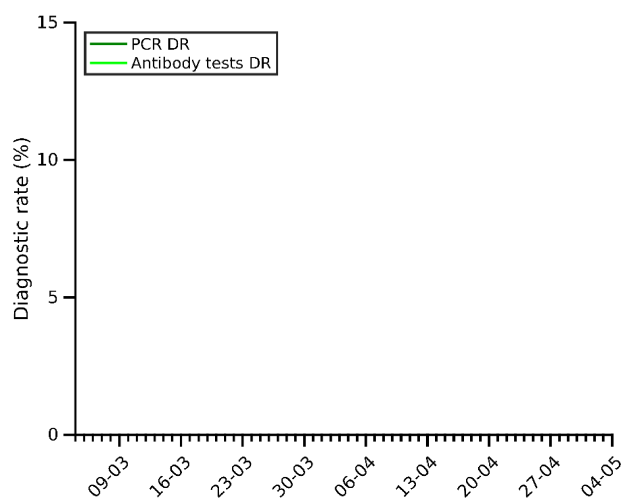
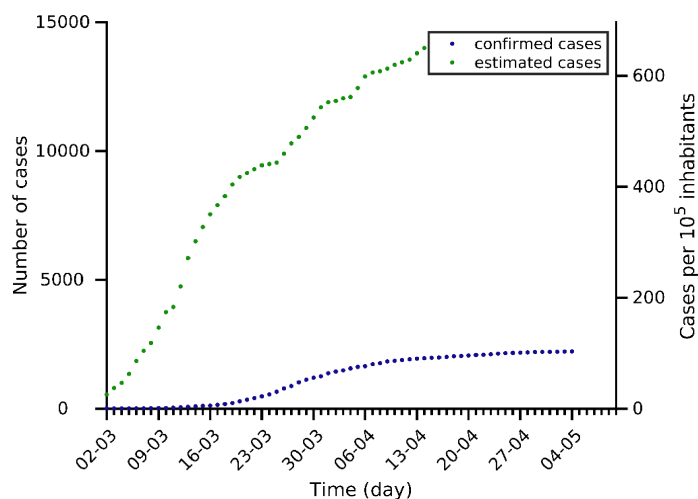
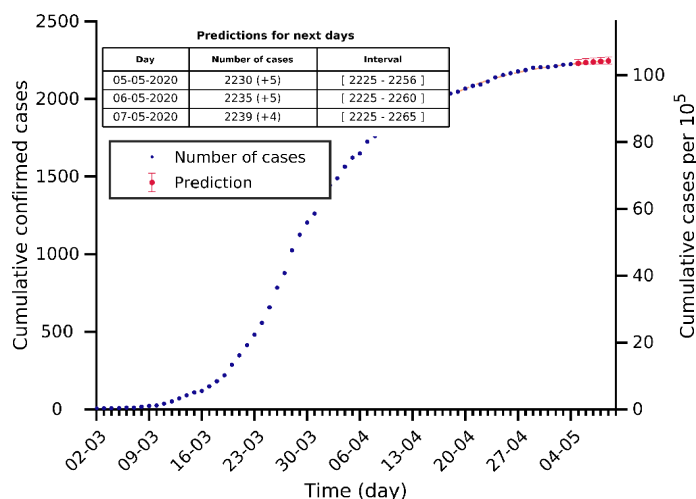
Extremadura 04-05-2020. Population: 1.1M. Current cumulated incidence: 267/10⁵



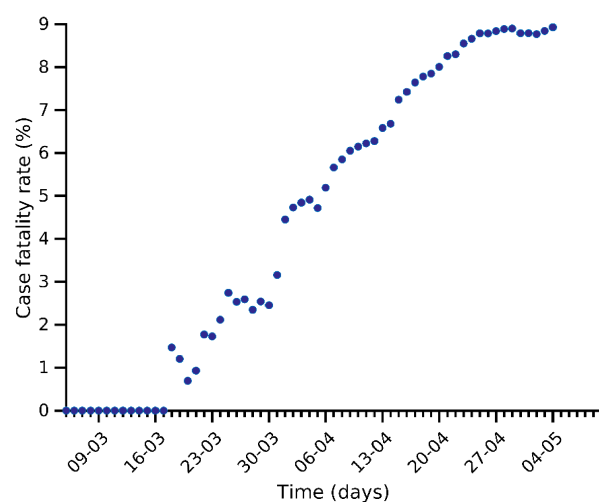
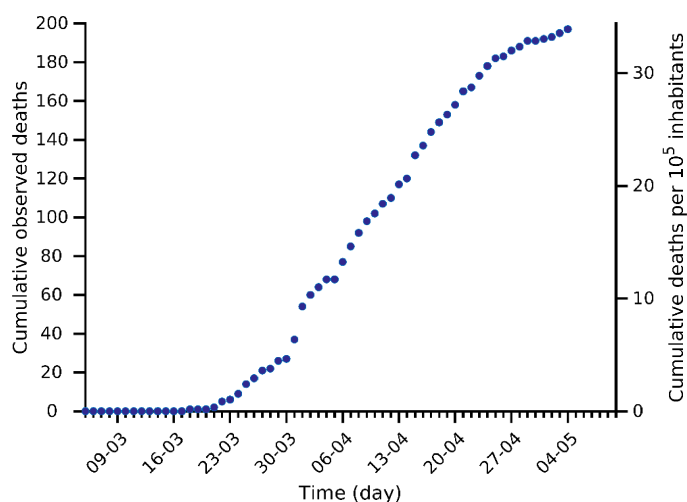
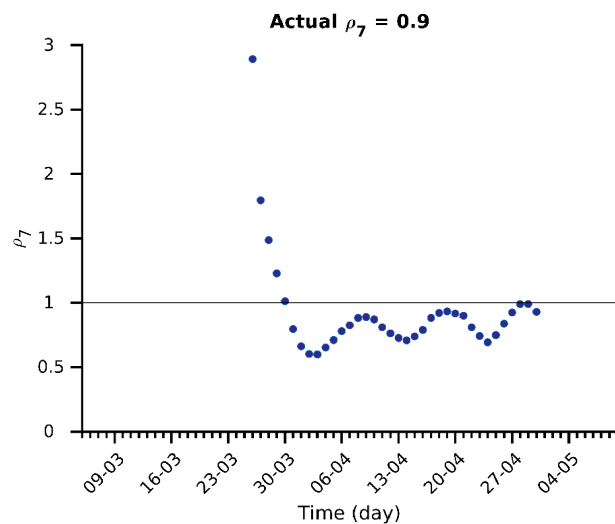
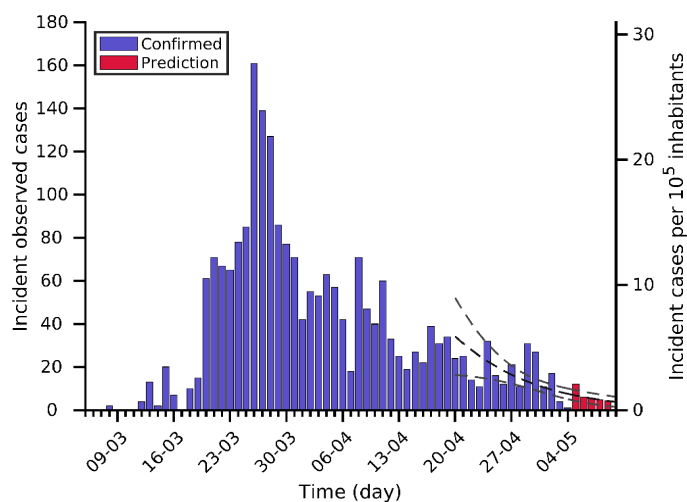
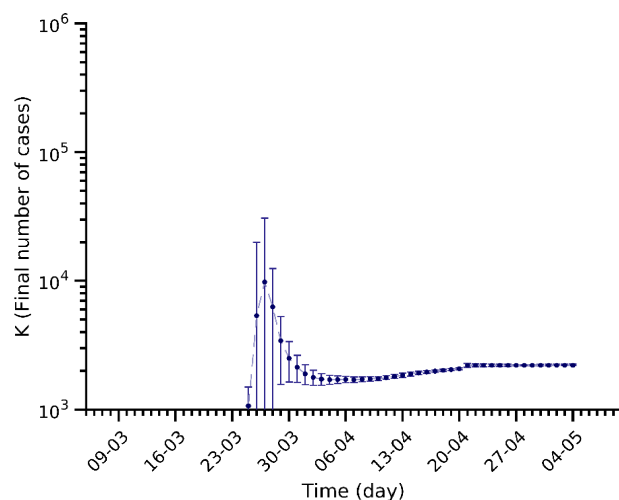
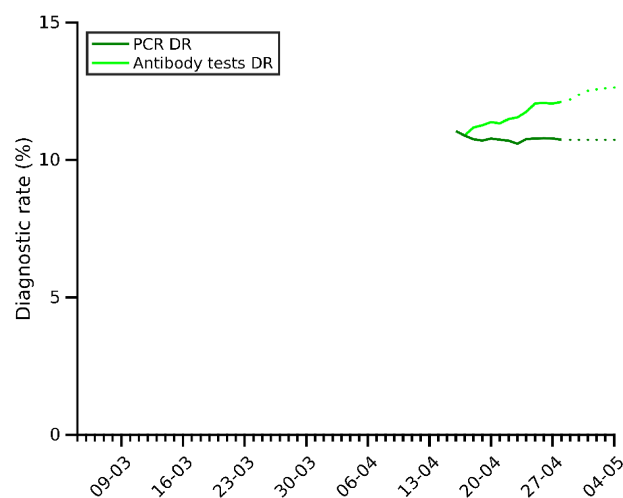
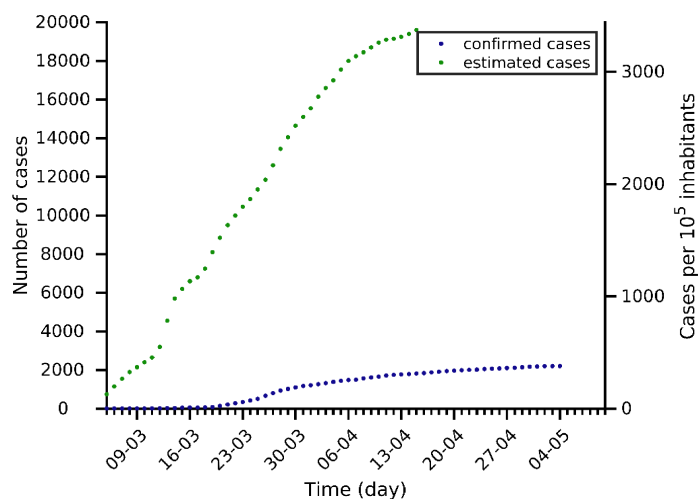
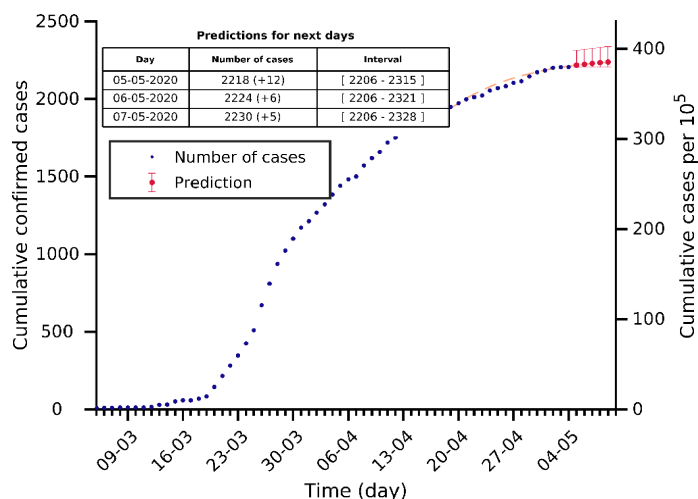
Asturias 04-05-2020. Population: 1.0M. Current cumulated incidence: 225/10⁵



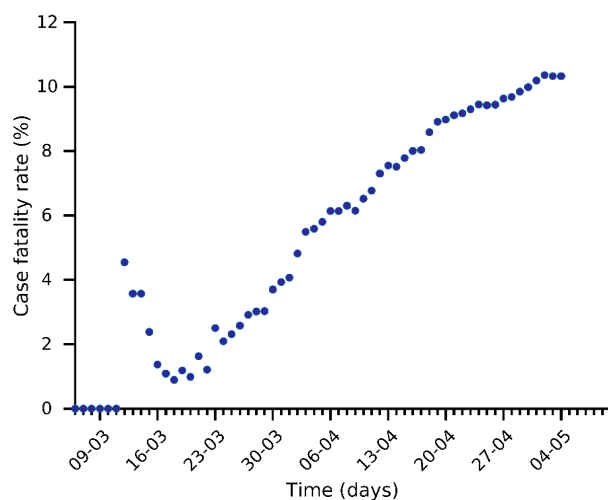
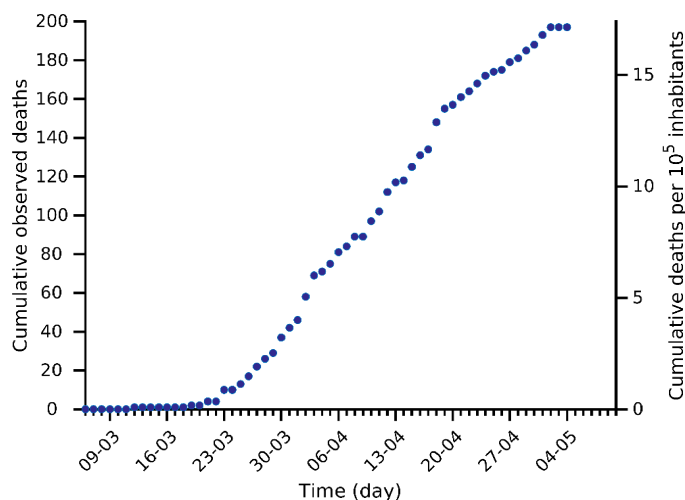
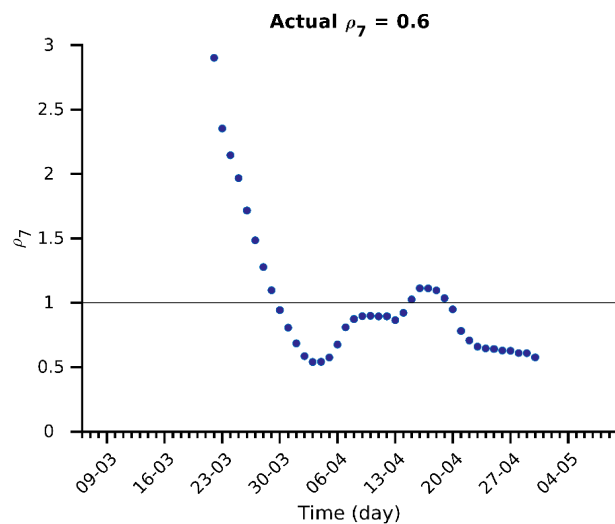
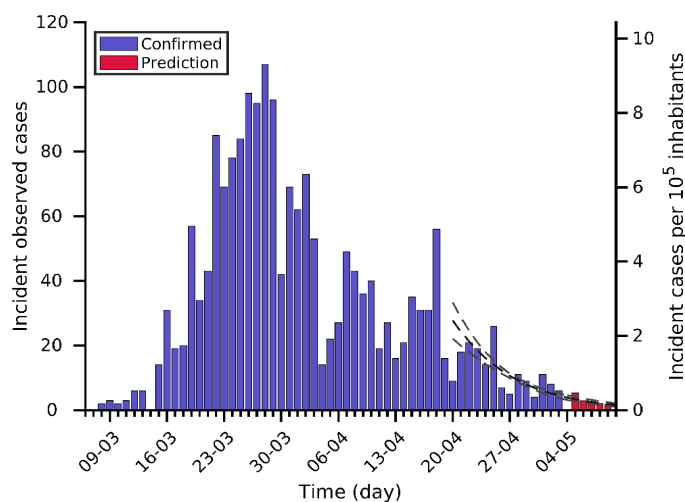
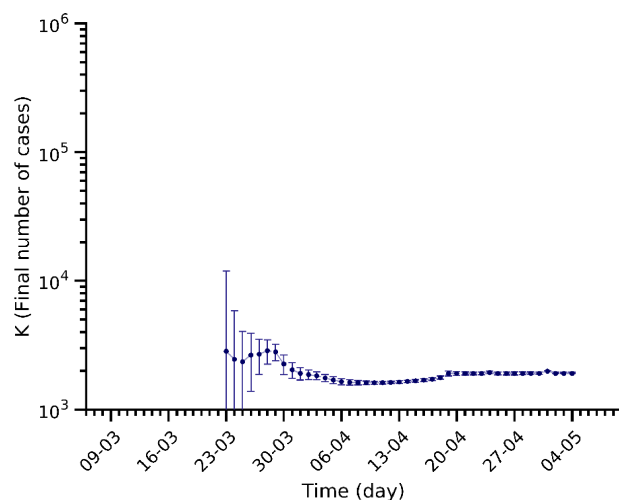
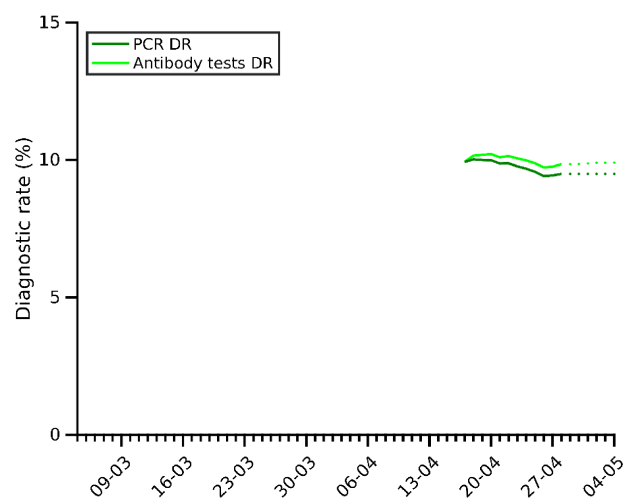
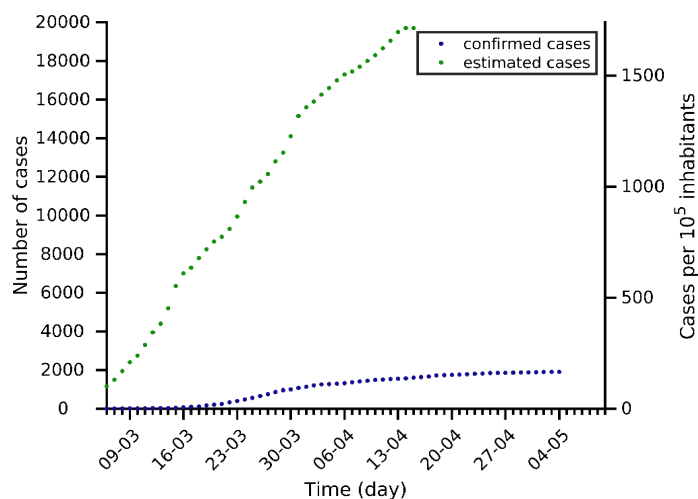
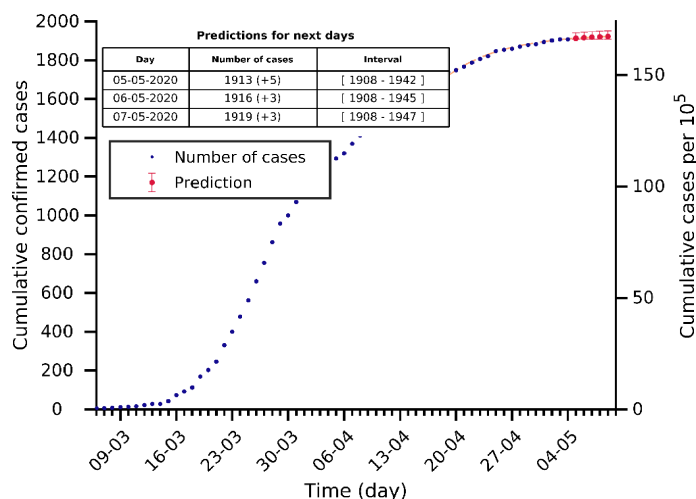
Canarias 04-05-2020. Population: 2.2M. Current cumulated incidence: 103/10⁵



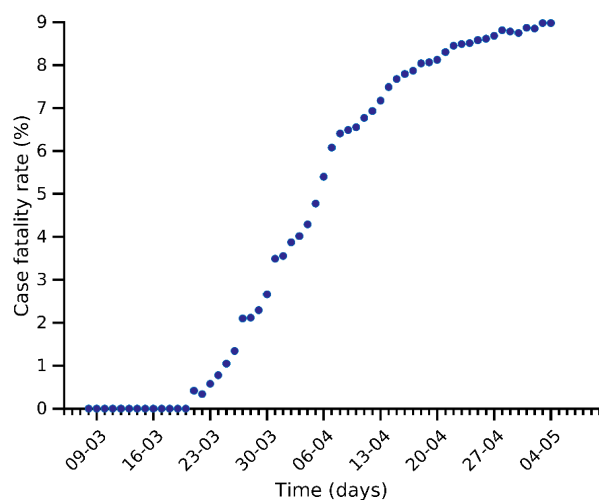
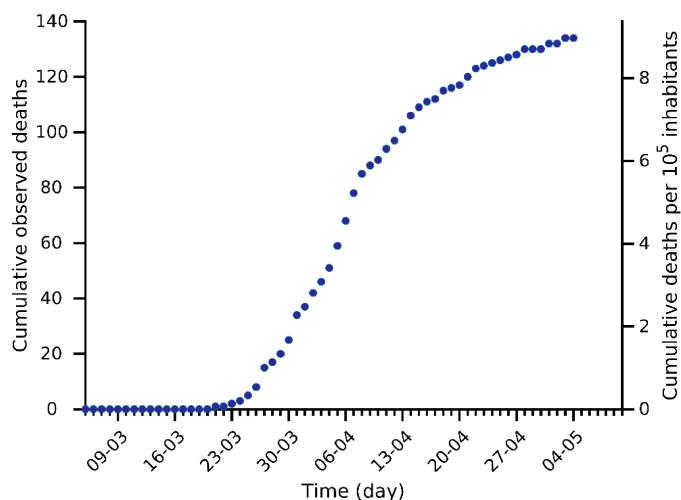
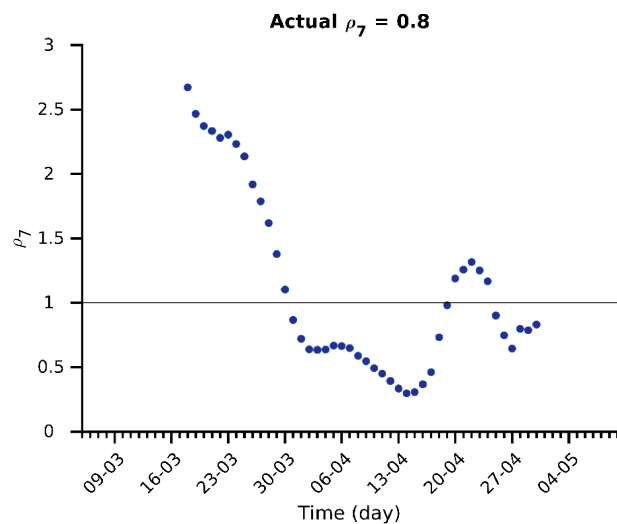
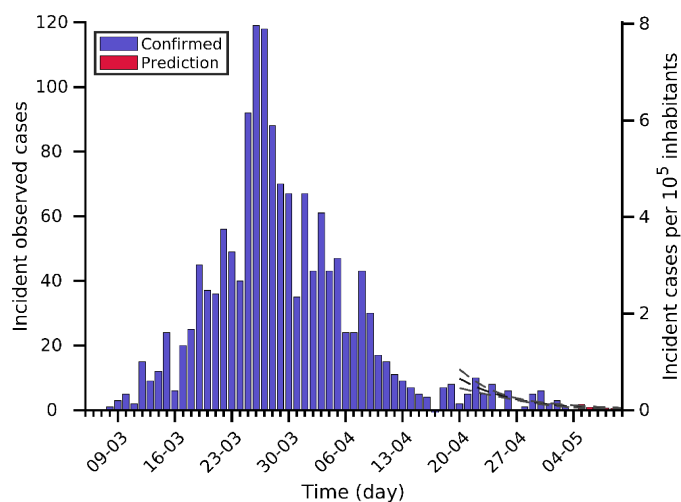
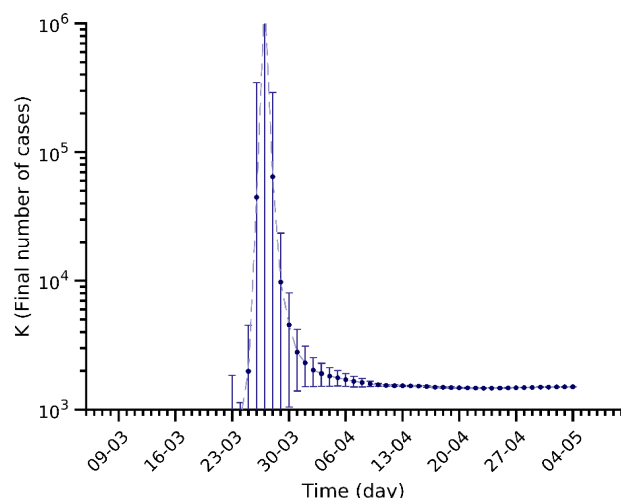
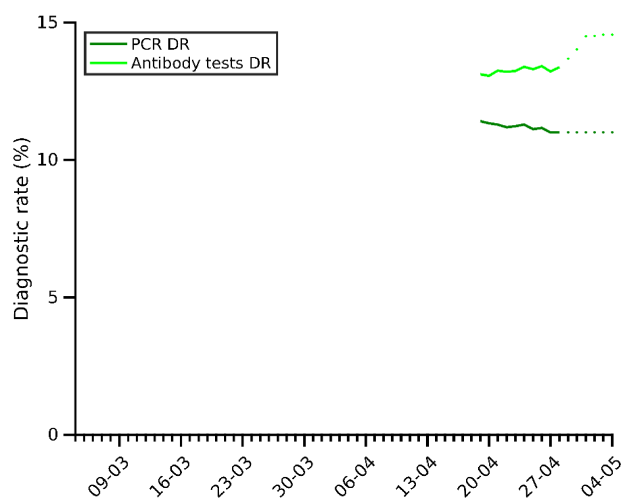
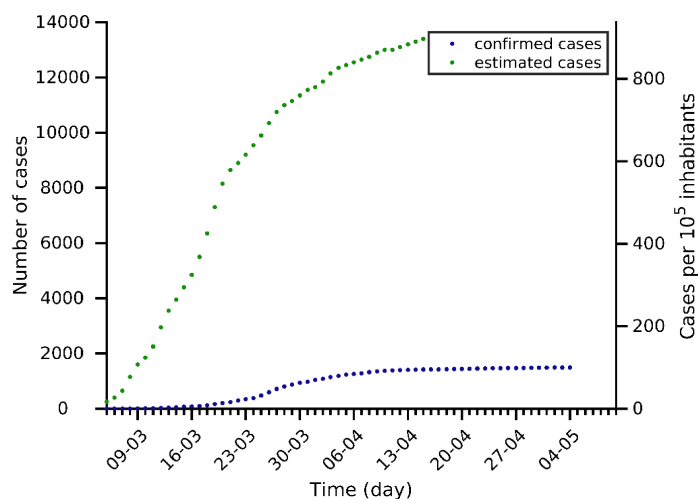
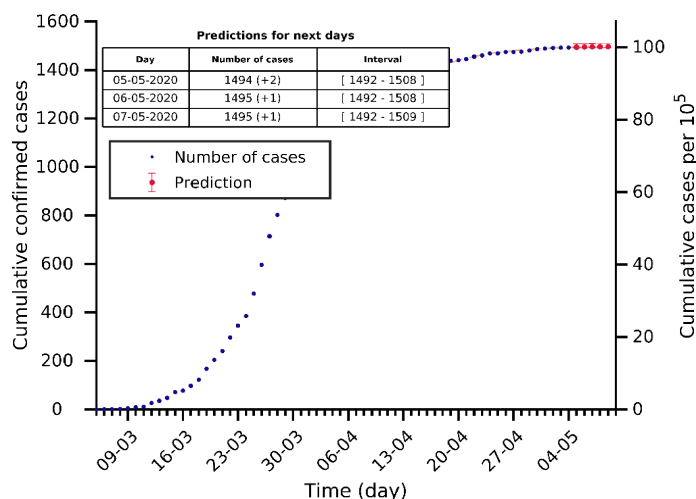
Cantabria 04-05-2020. Population: 0.6M. Current cumulated incidence: 380/10⁵



Baleares 04-05-2020. Population: 1.1M. Current cumulated incidence: 166/10⁵



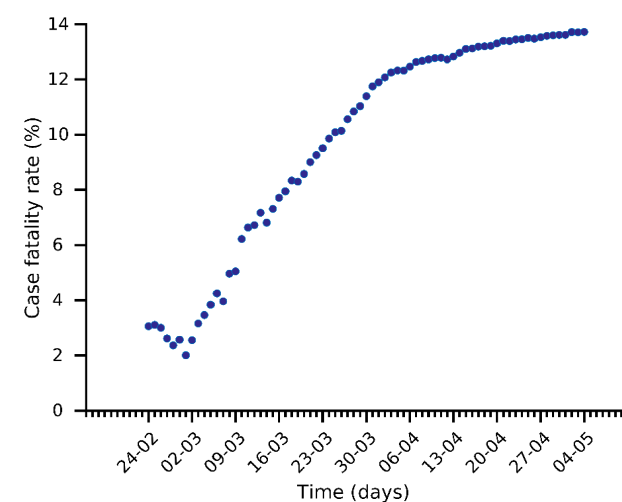
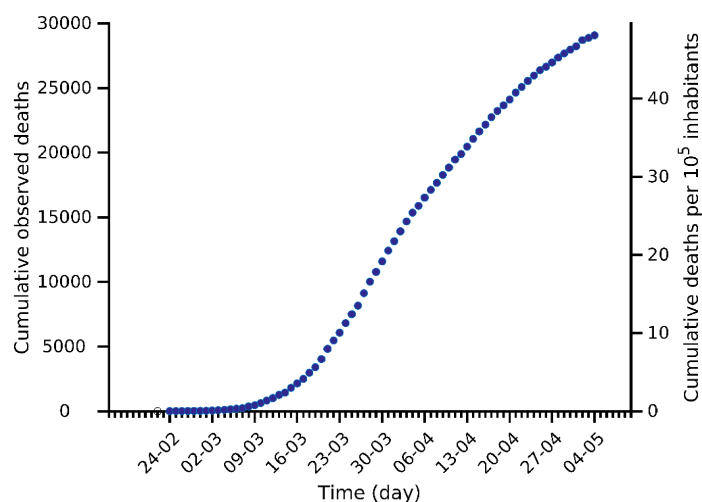
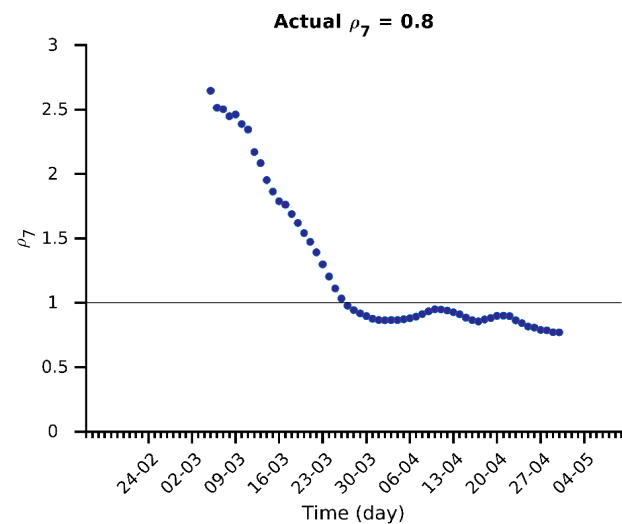
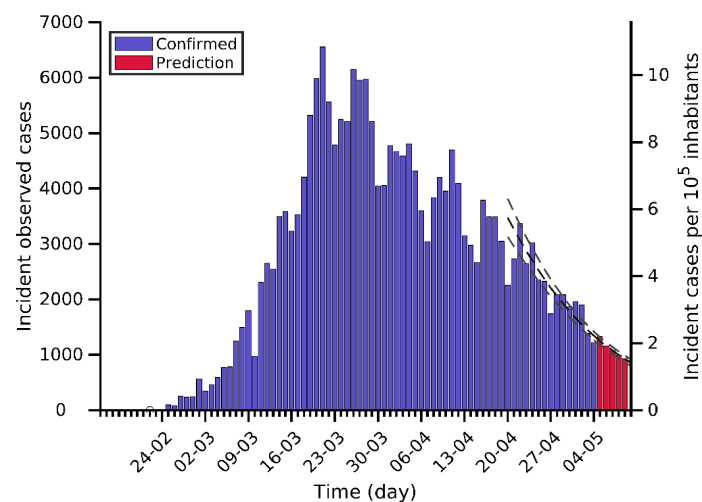
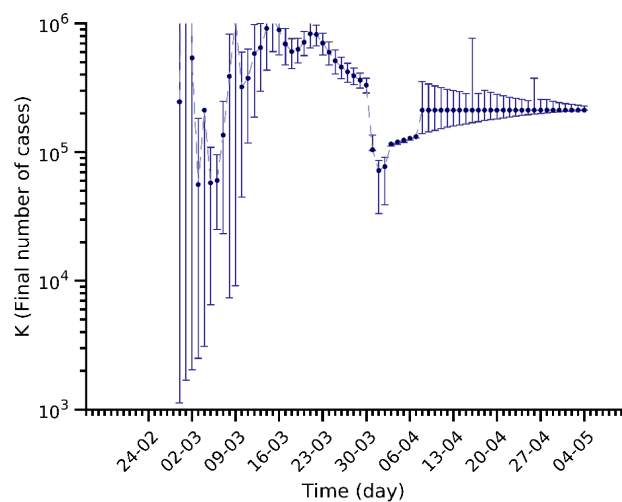
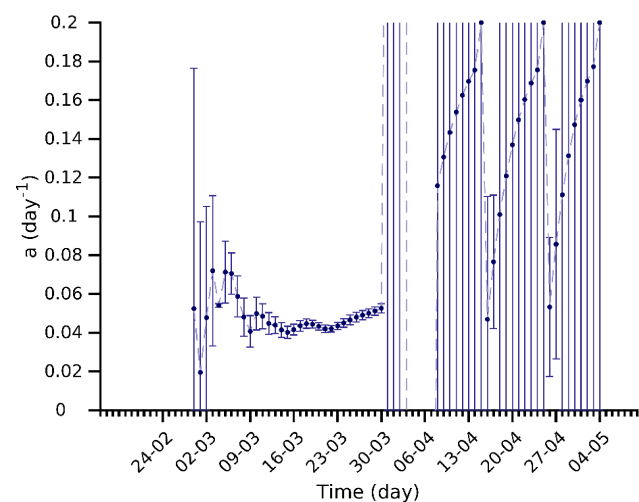
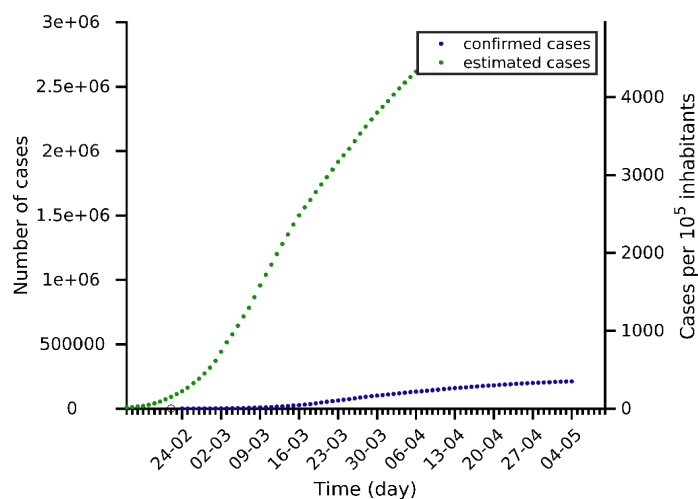
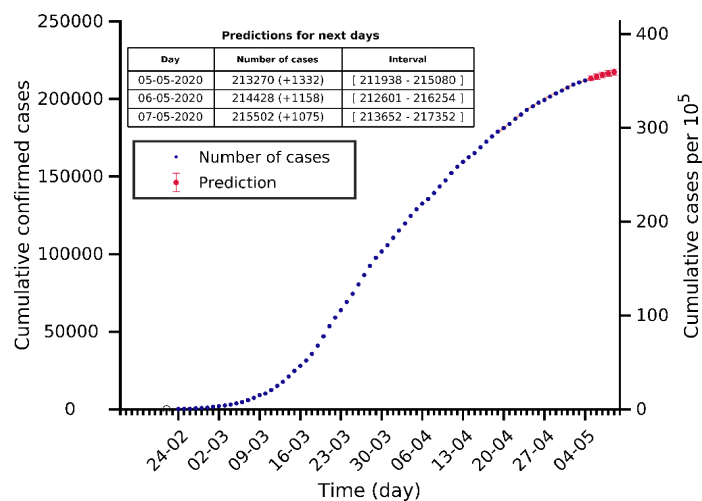
Murcia 04-05-2020. Population: 1.5M. Current cumulated incidence: 100/10⁵



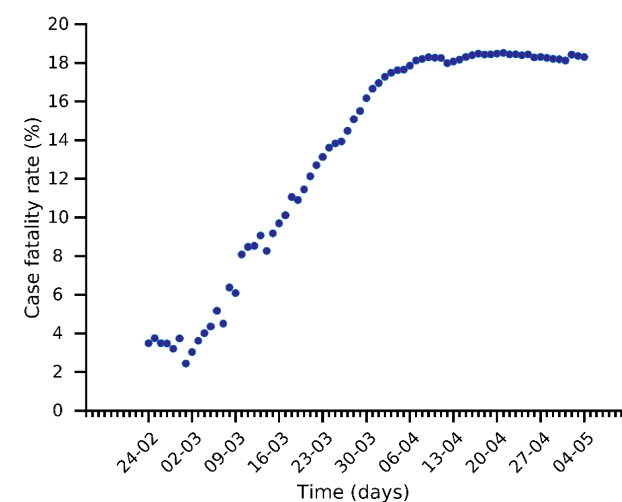
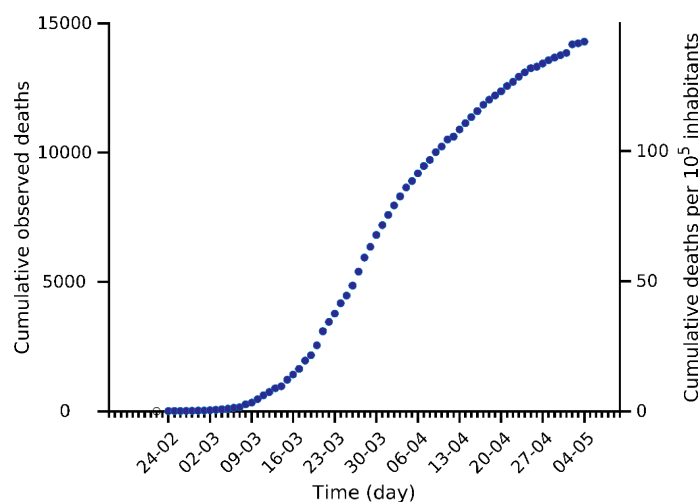
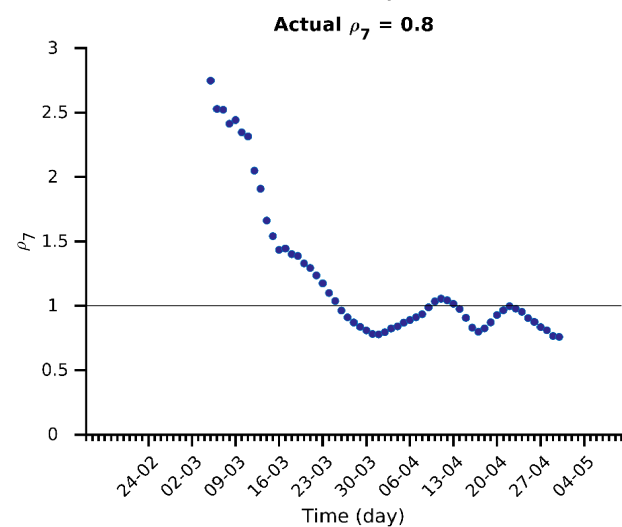
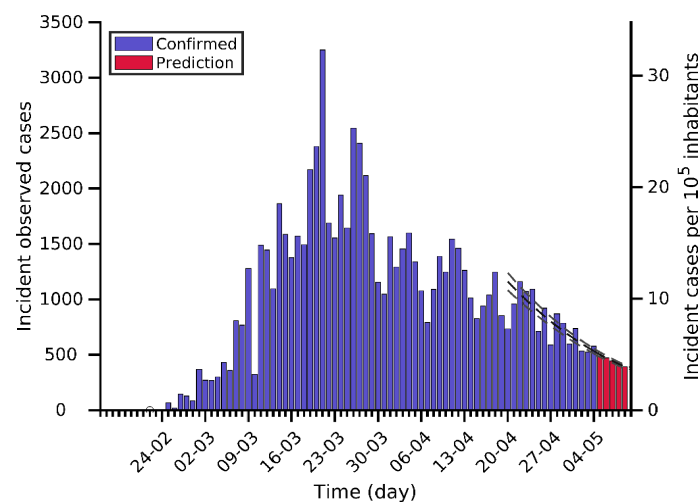
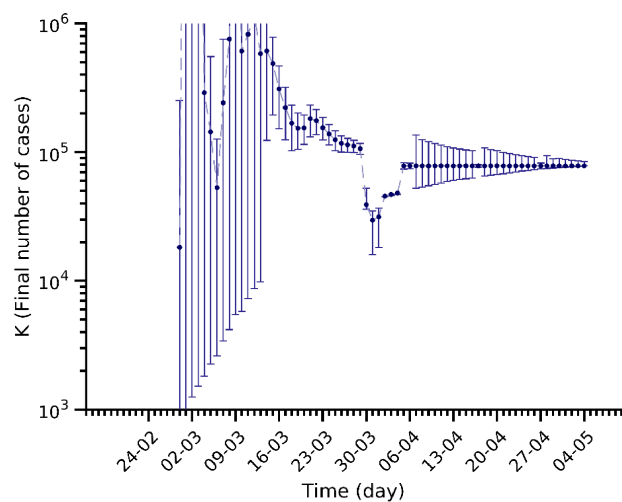
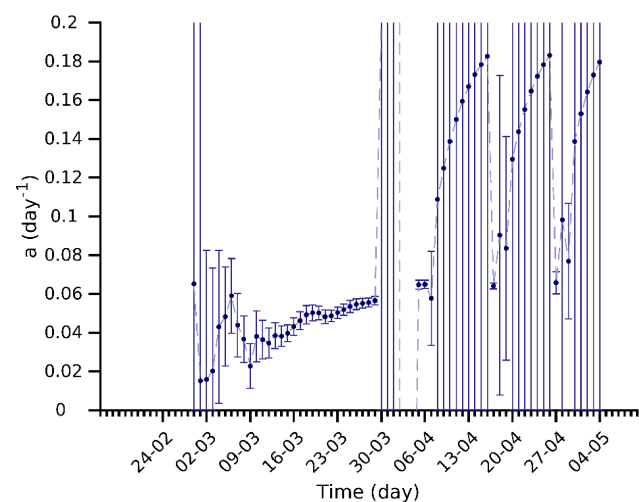
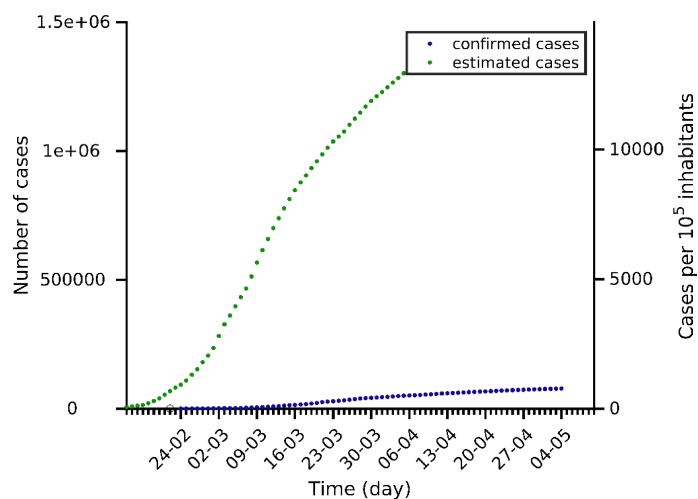
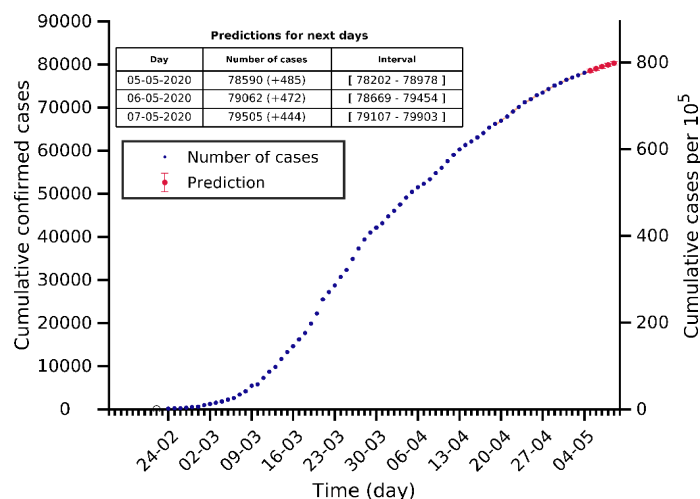
(3) Analysis and prediction of COVID-19 for Italy and its regions

Data obtained from: <https://github.com/pcm-dpc/COVID-19/tree/master/dati-andamento-nazionale>

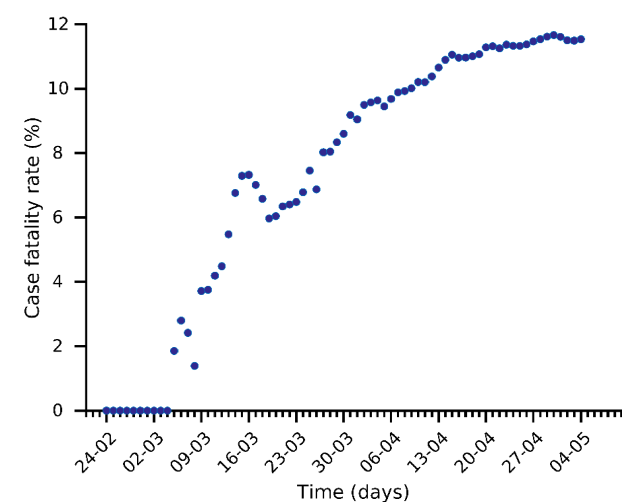
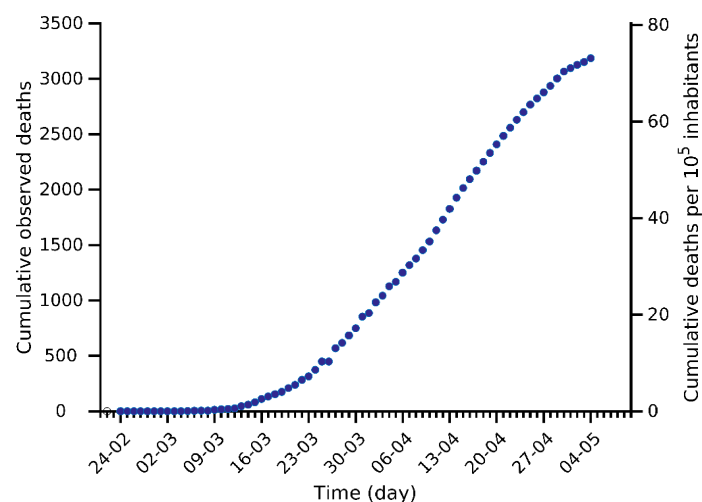
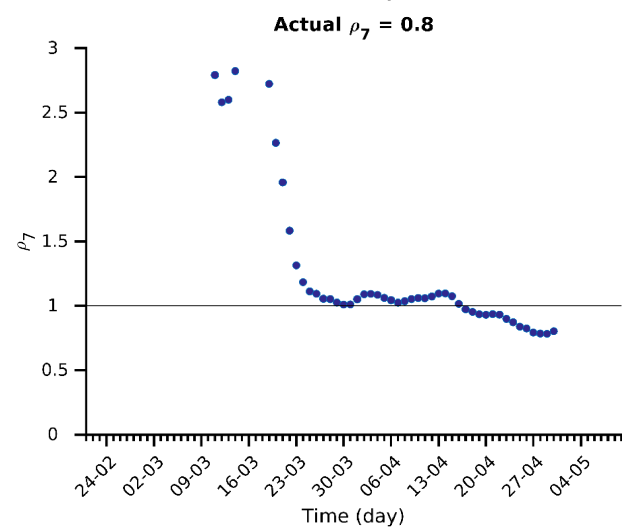
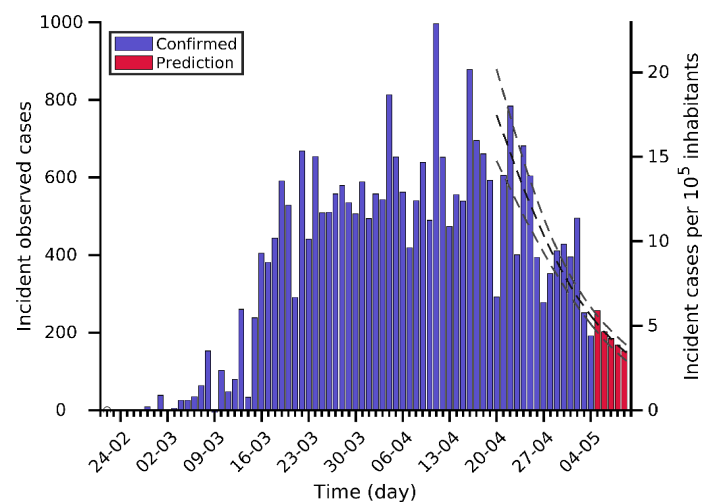
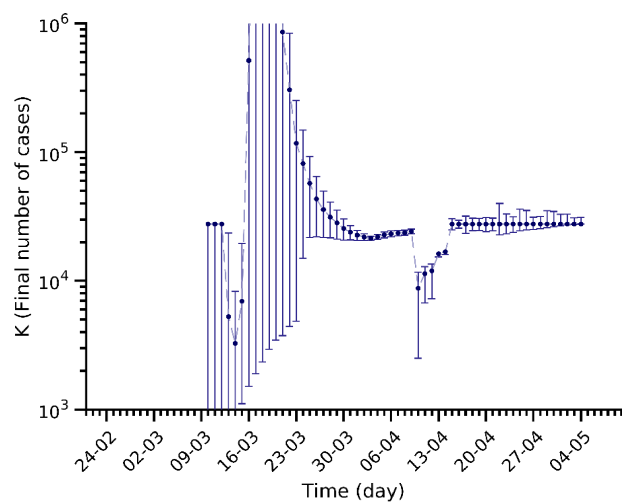
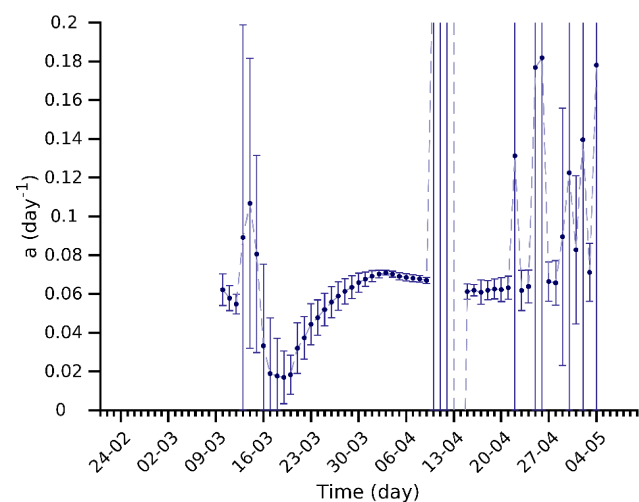
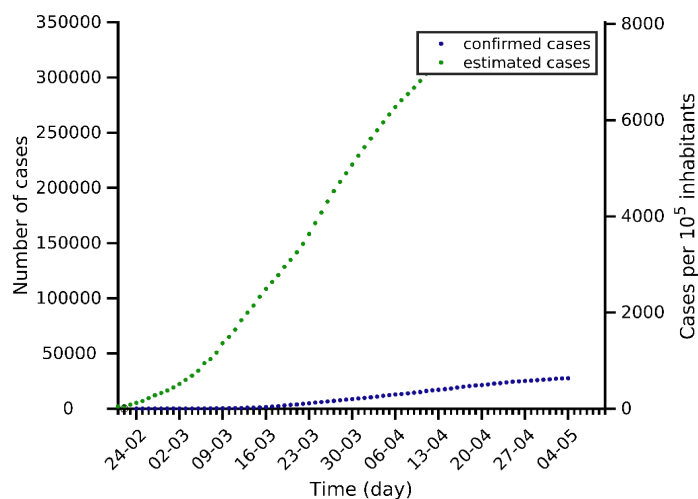
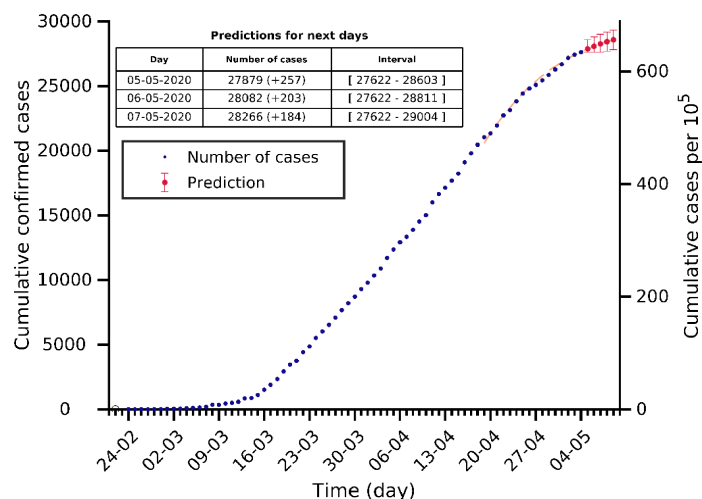
Italy 04-05-2020. Population: 60.5M. Current cumulated incidence: 351/10⁵



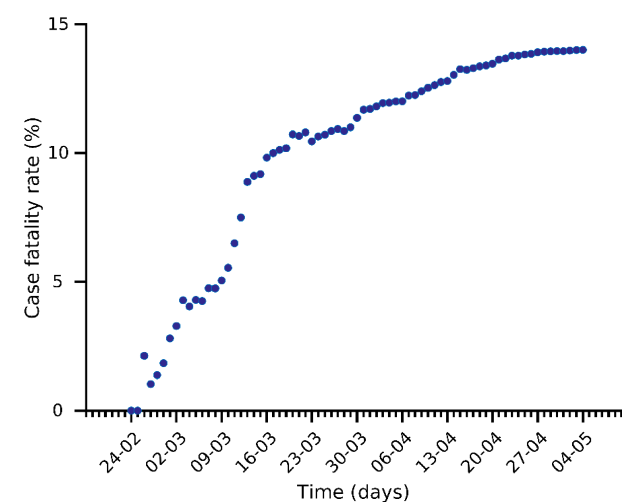
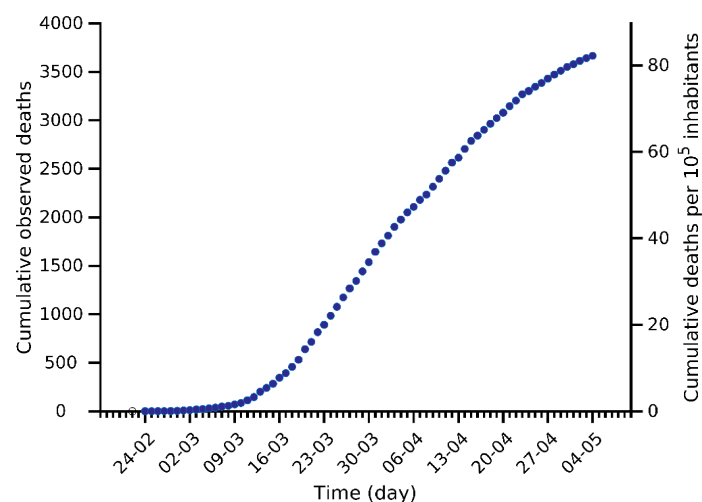
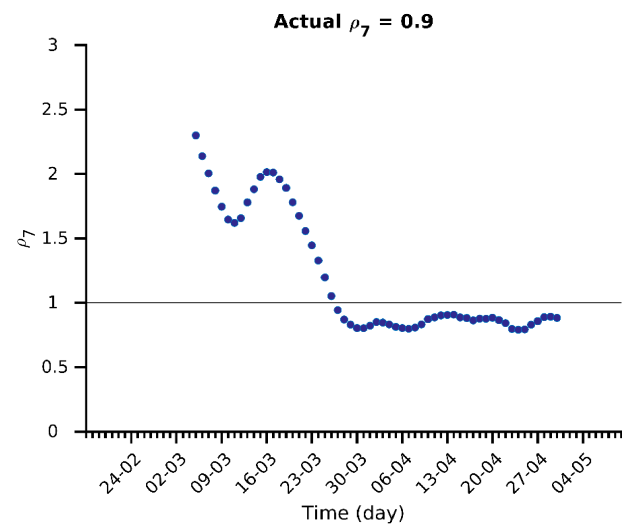
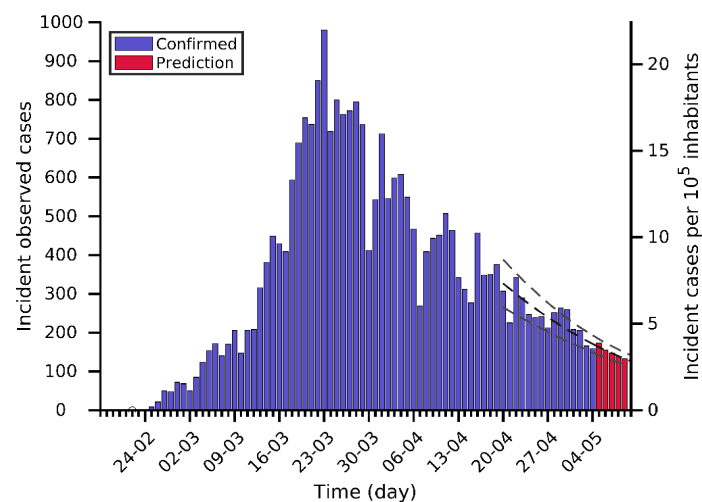
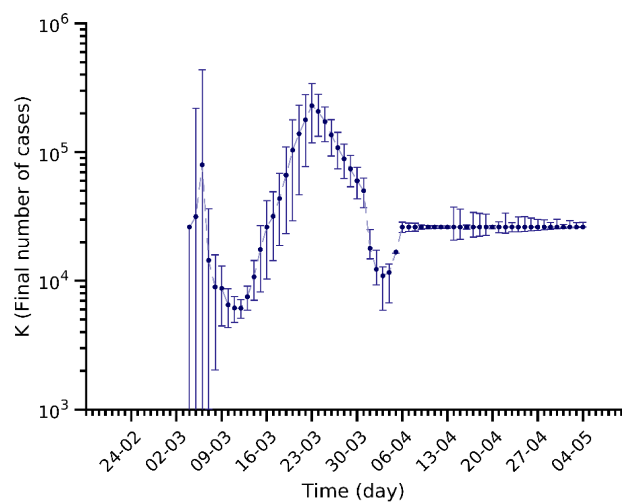
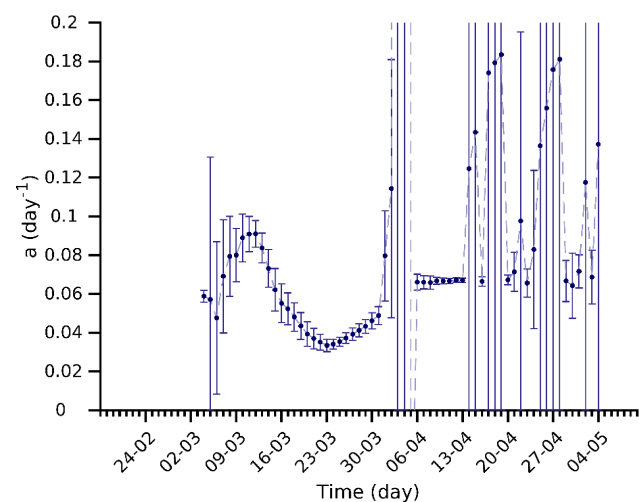
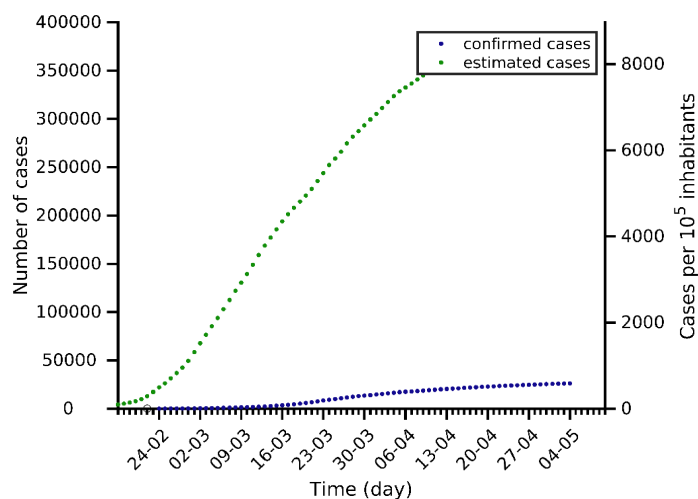
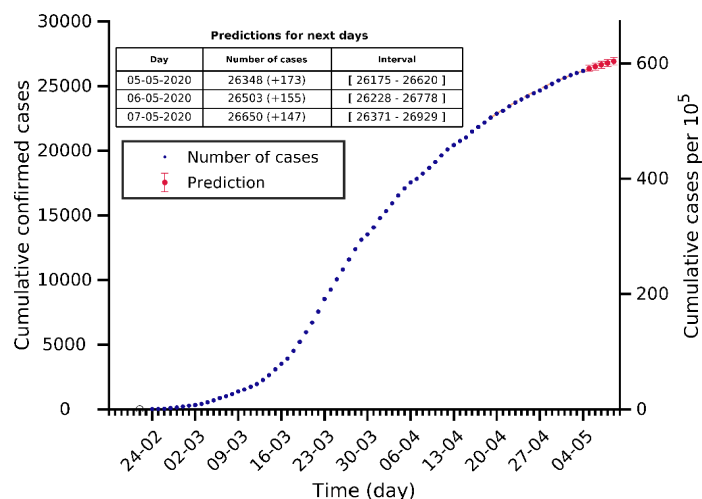
Lombardia 04-05-2020. Population: 10.1M. Current cumulated incidence: 776/10⁵



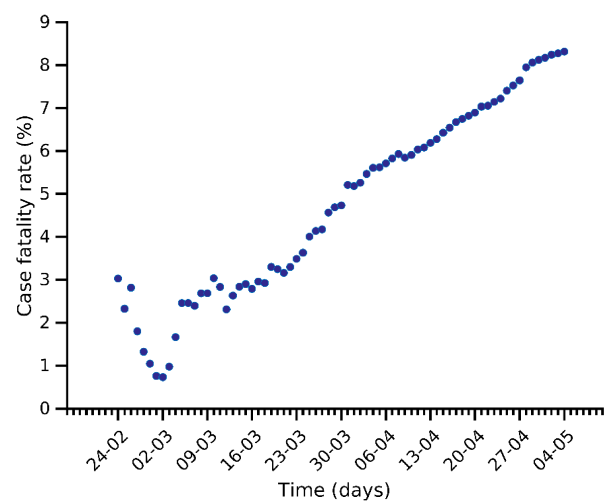
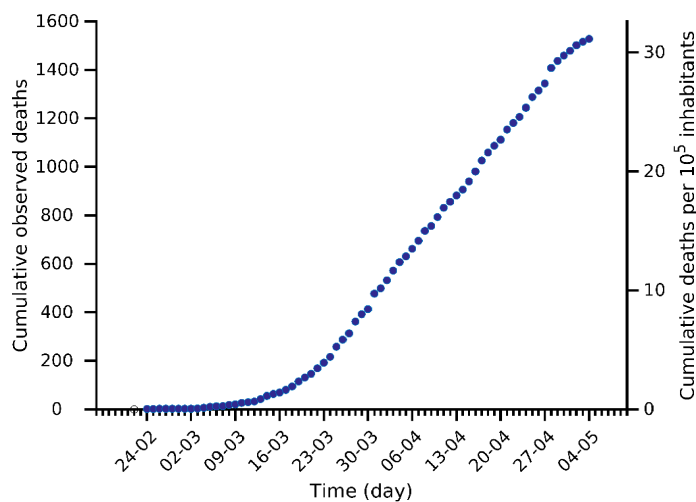
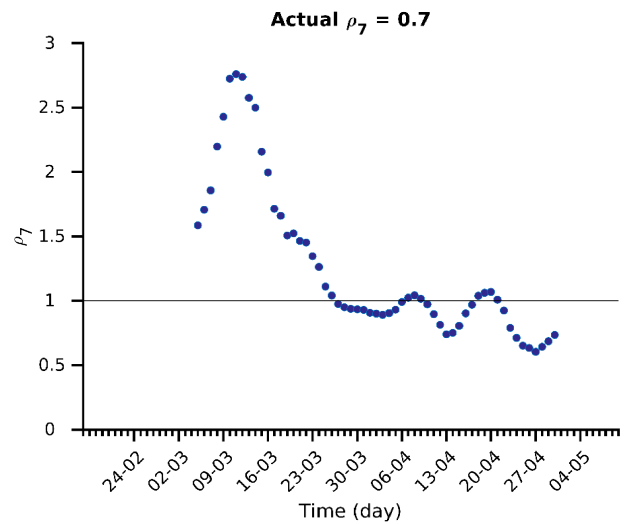
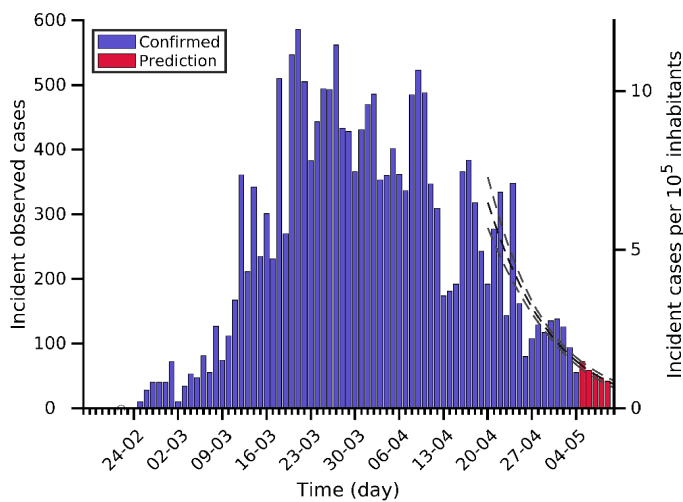
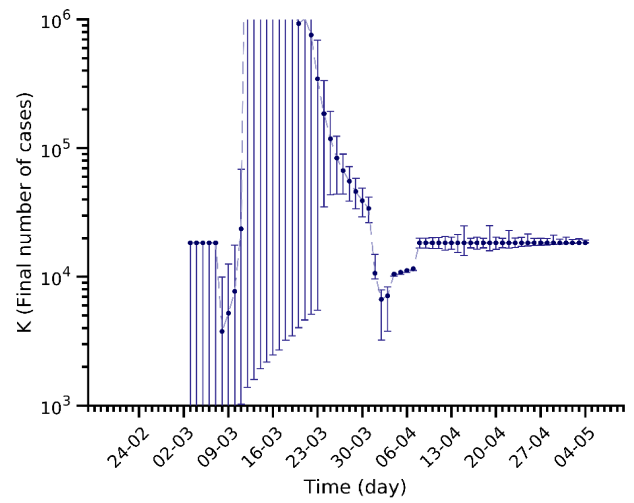
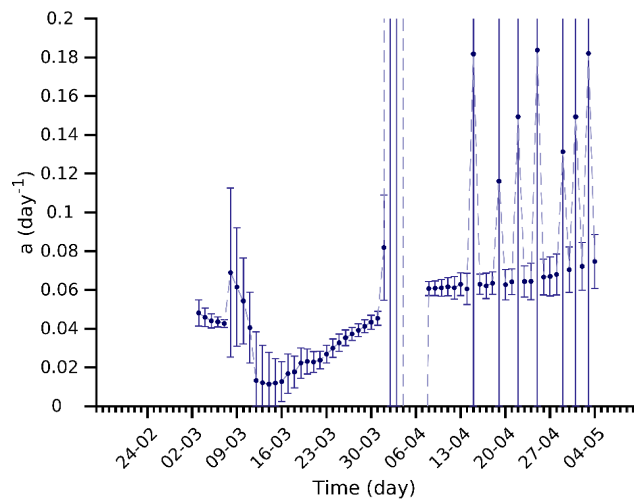
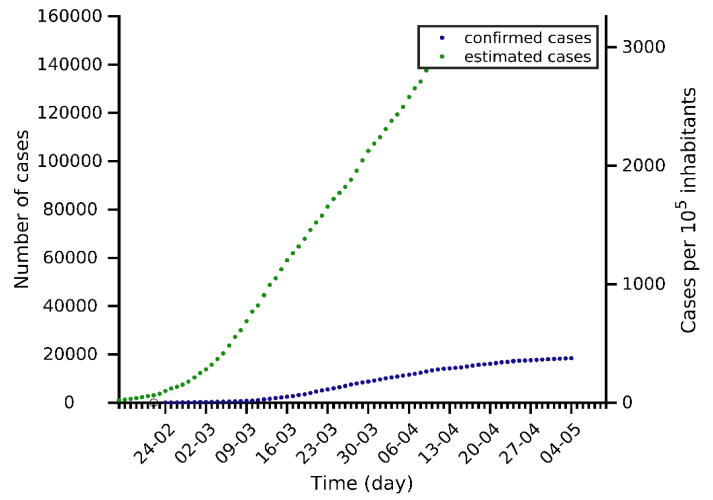
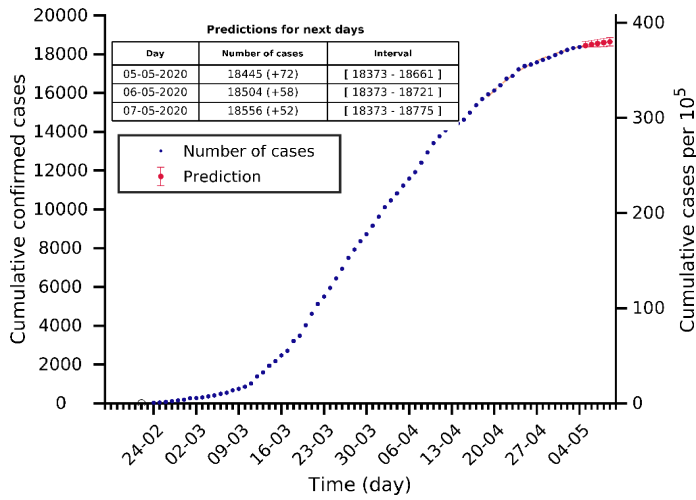
Piemonte 04-05-2020. Population: 4.4M. Current cumulated incidence: 634/10⁵



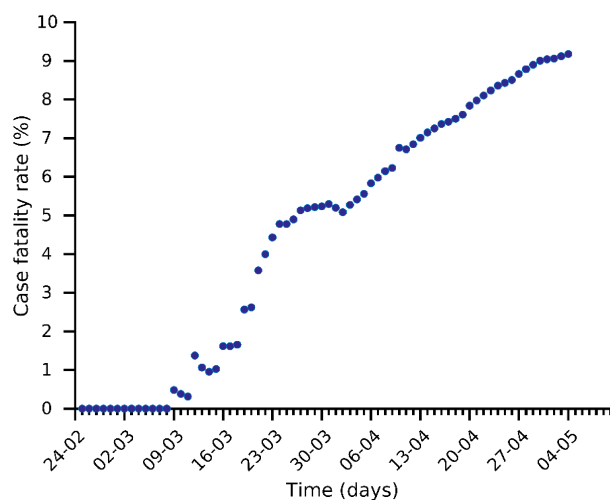
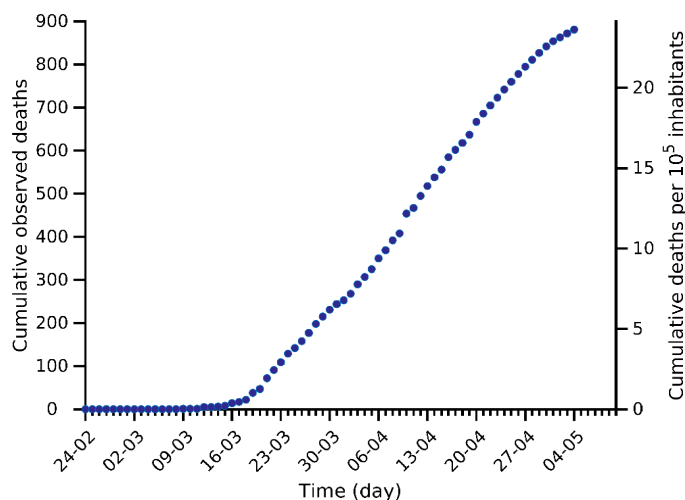
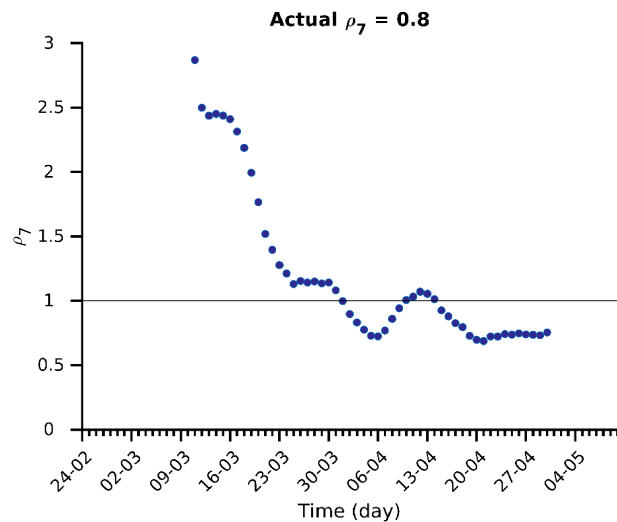
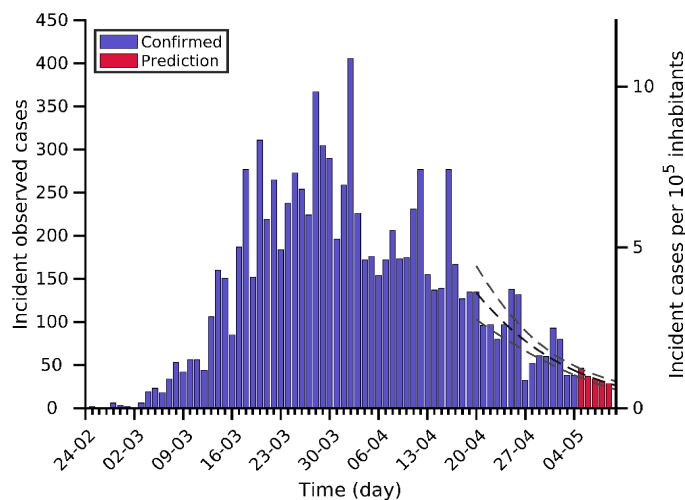
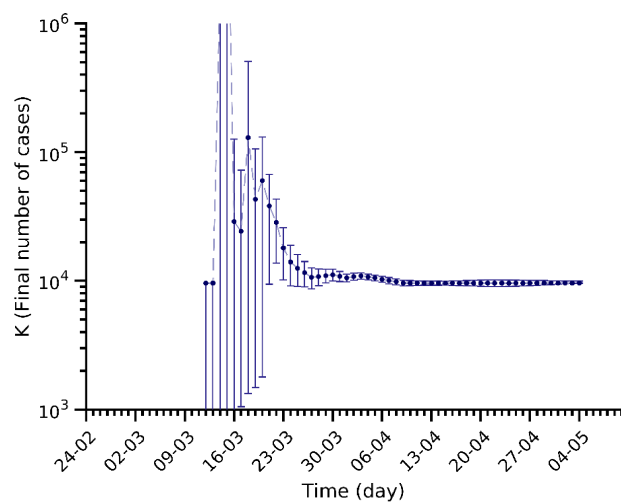
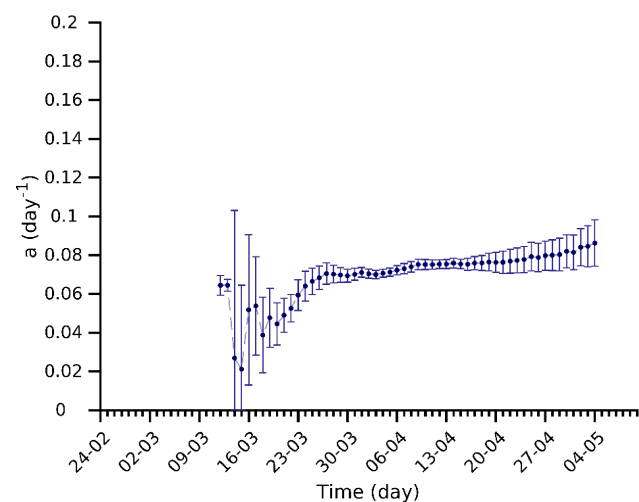
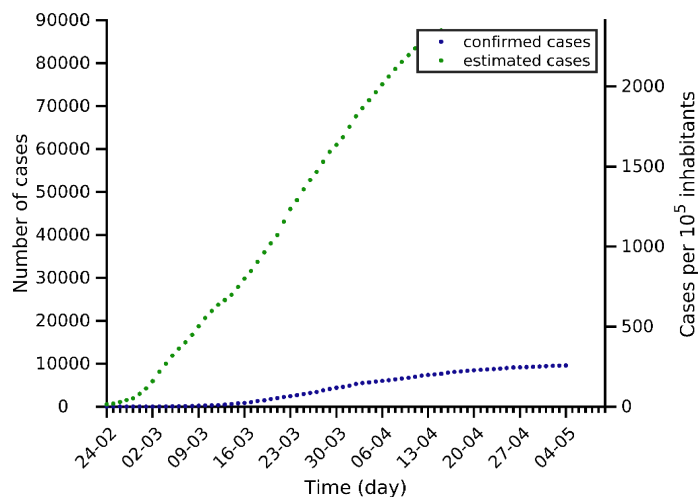
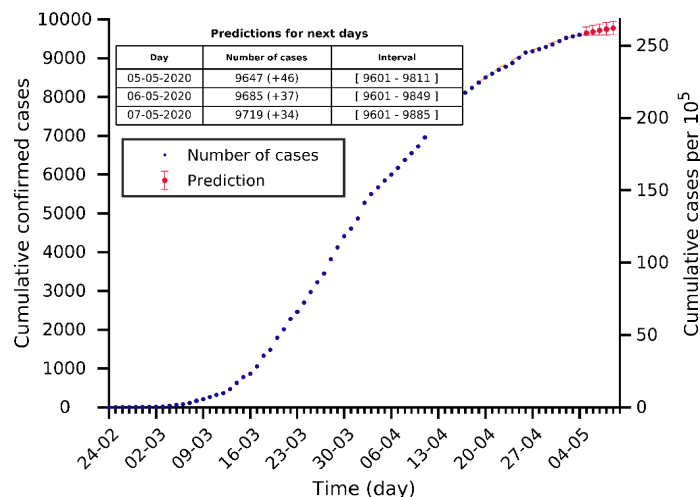
Emilia Romagna 04-05-2020. Population: 4.5M. Current cumulated incidence: 587/10⁵



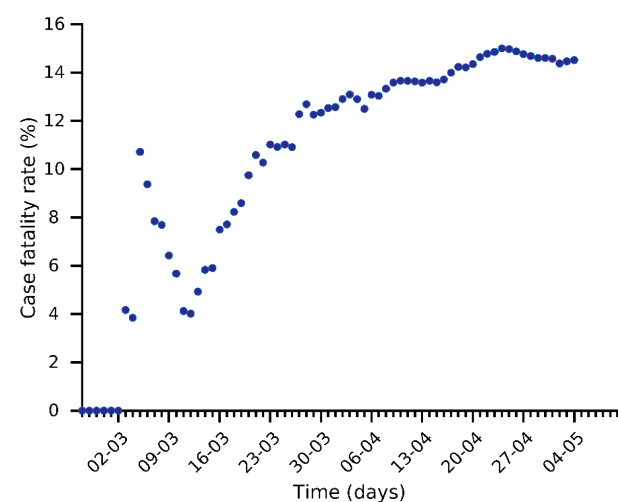
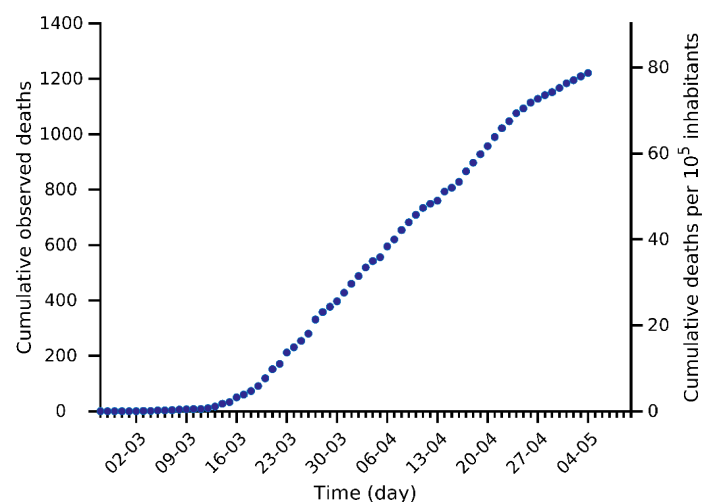
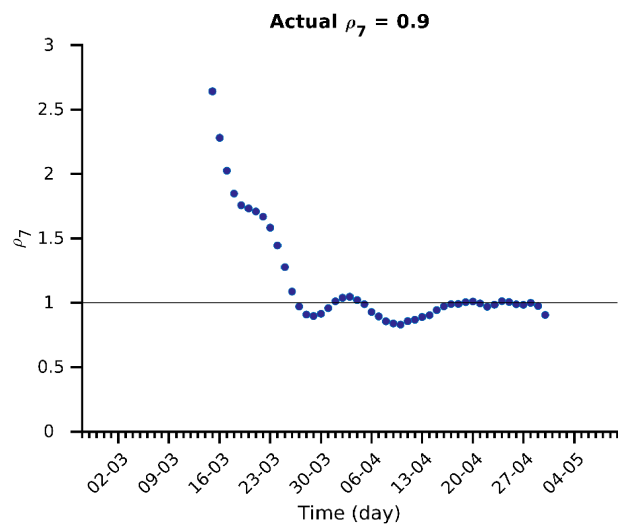
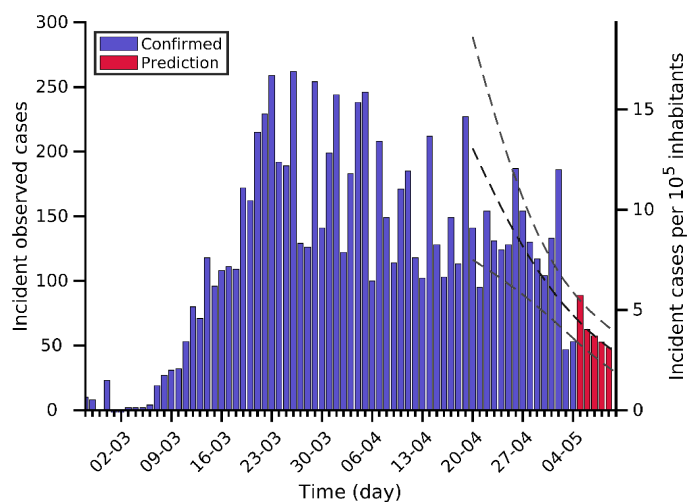
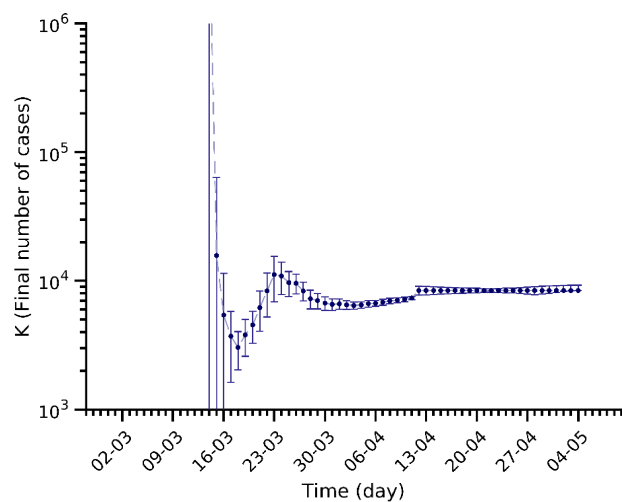
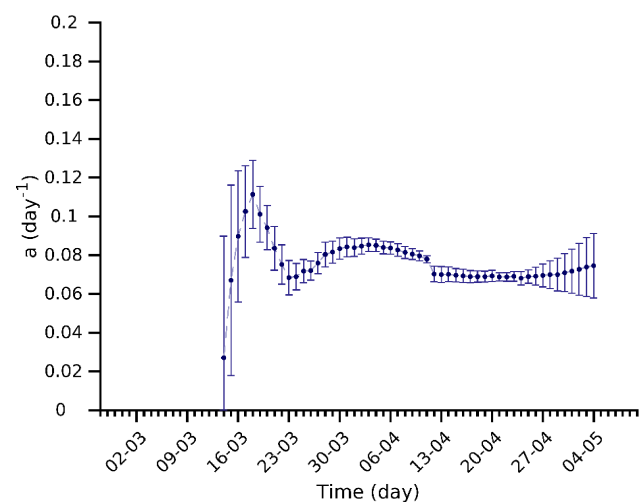
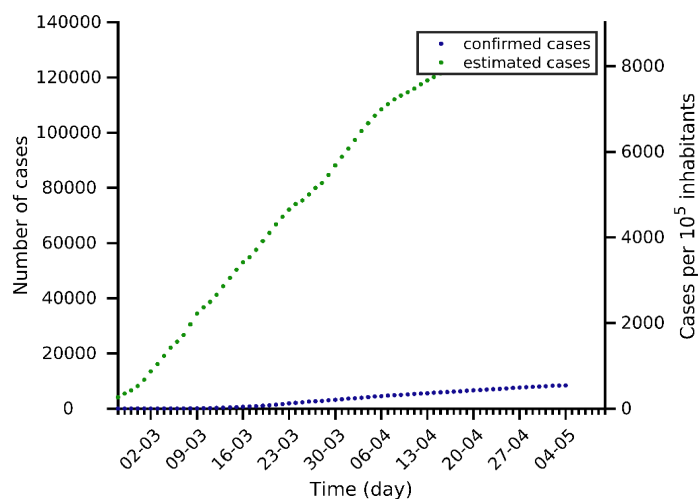
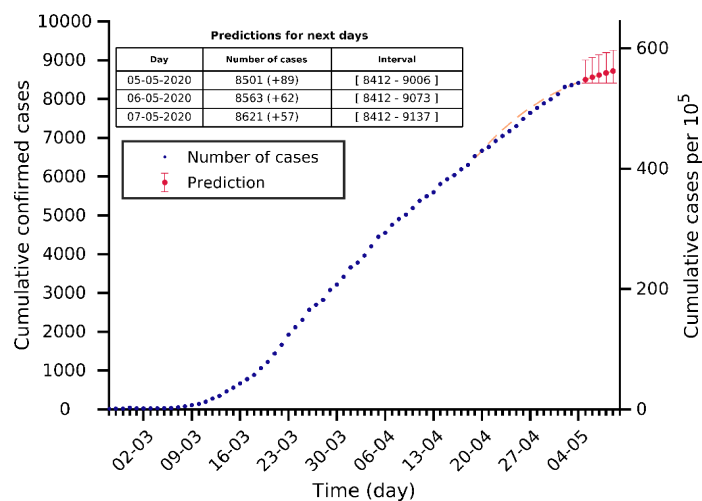
Veneto 04-05-2020. Population: 4.9M. Current cumulated incidence: 375/10⁵



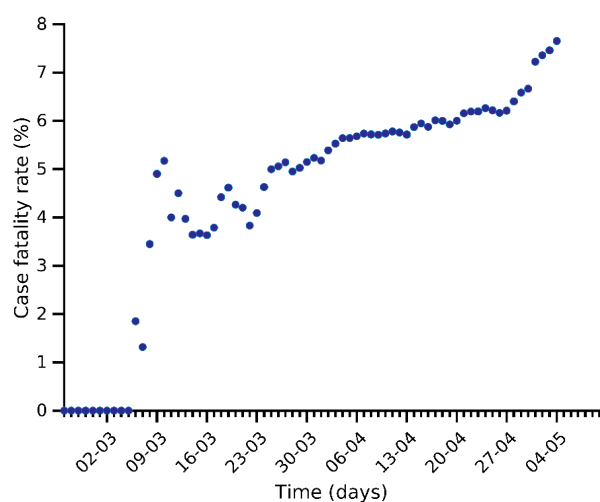
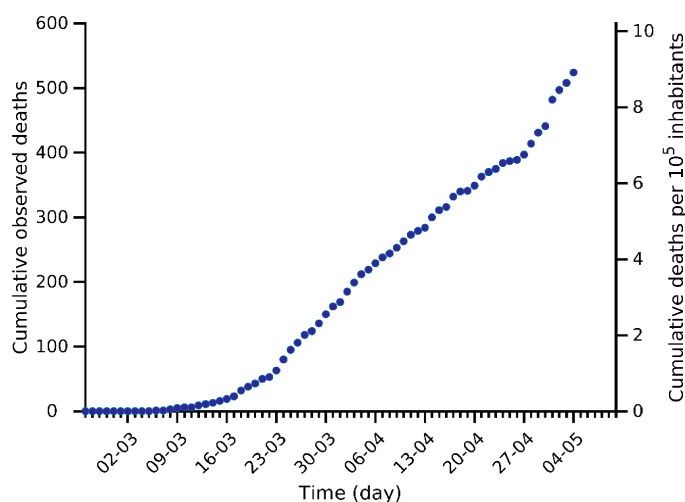
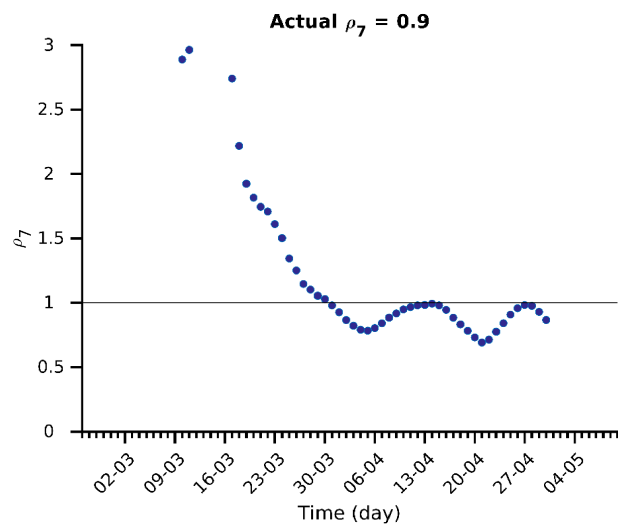
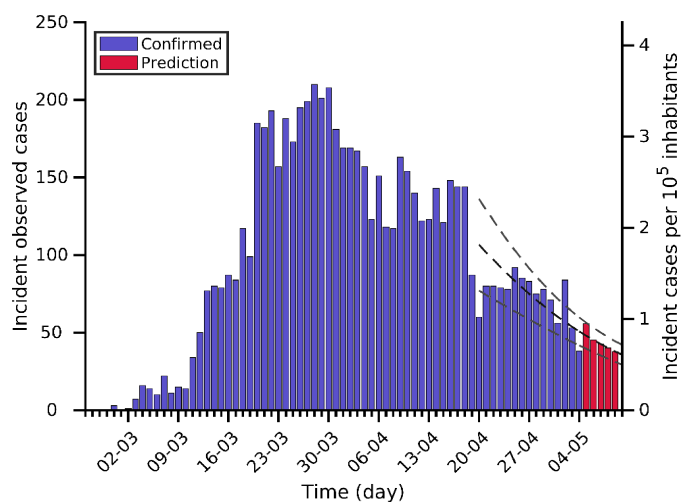
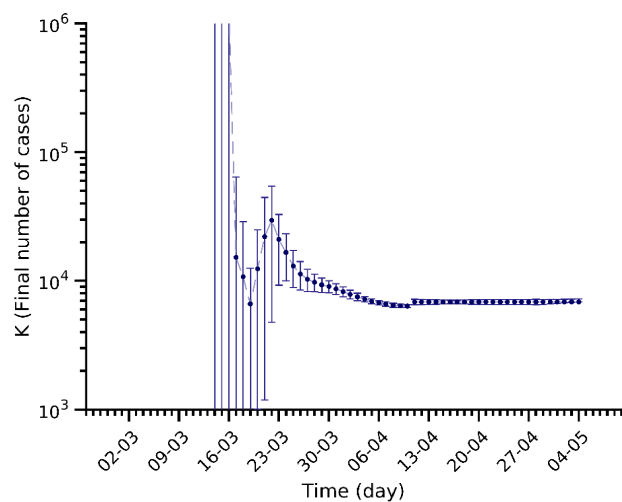
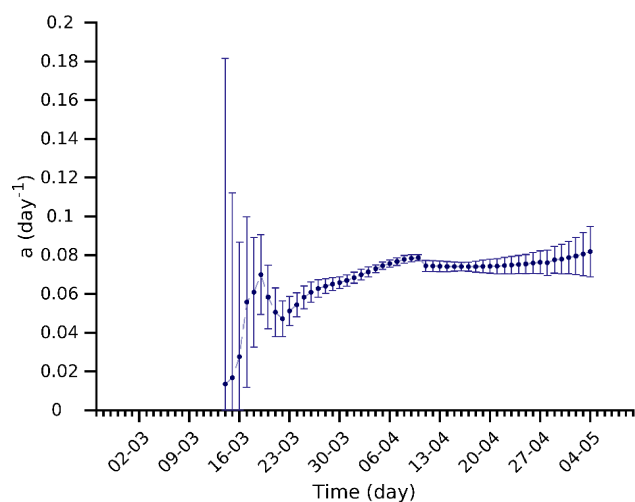
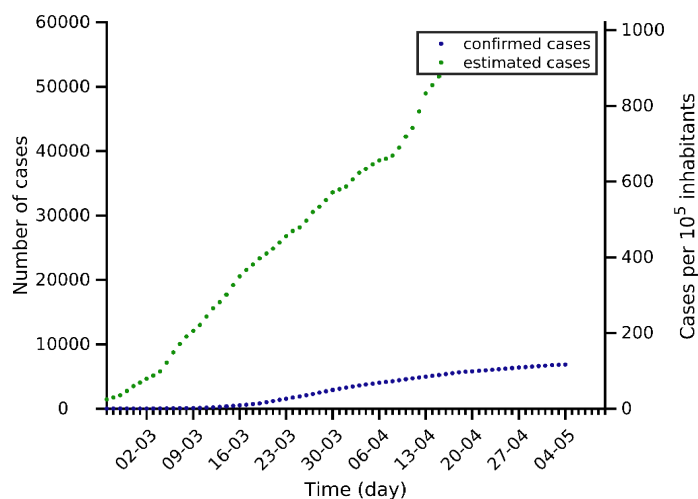
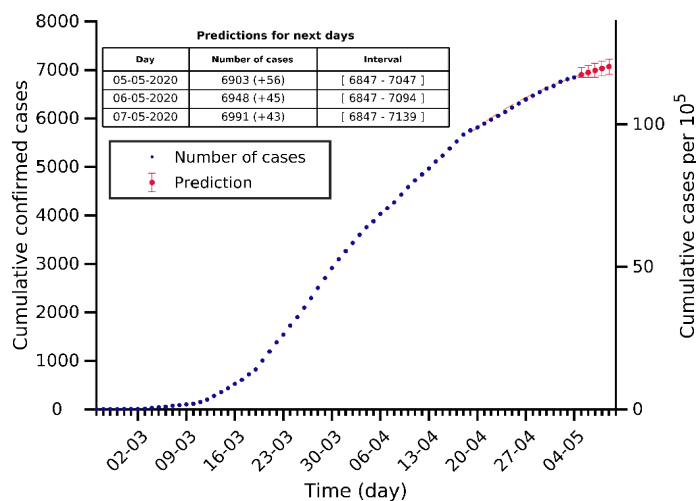
Toscana 04-05-2020. Population: 3.7M. Current cumulated incidence: 257/10⁵



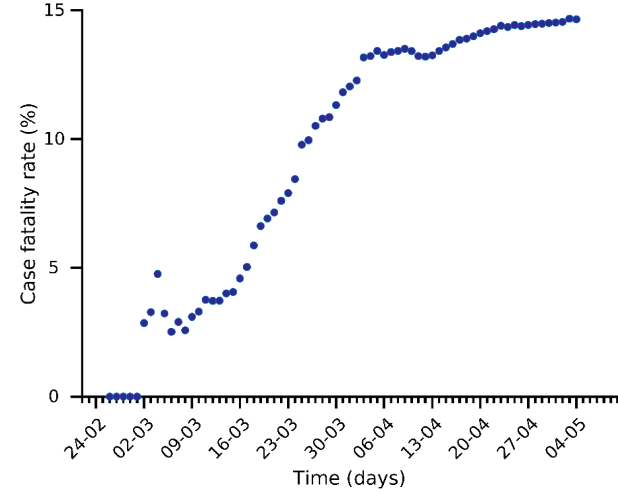
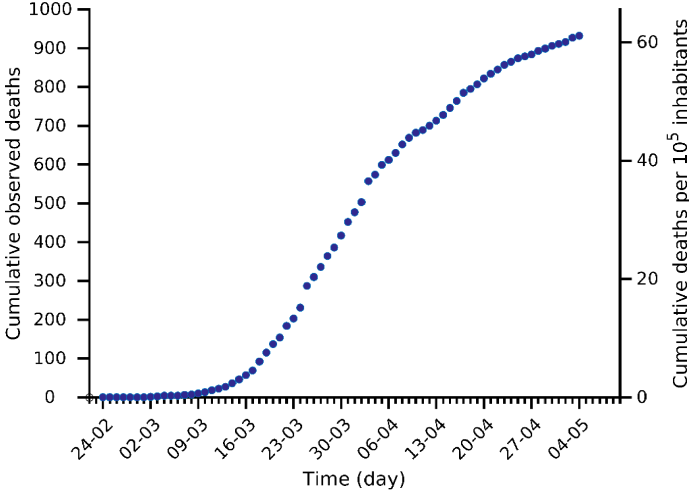
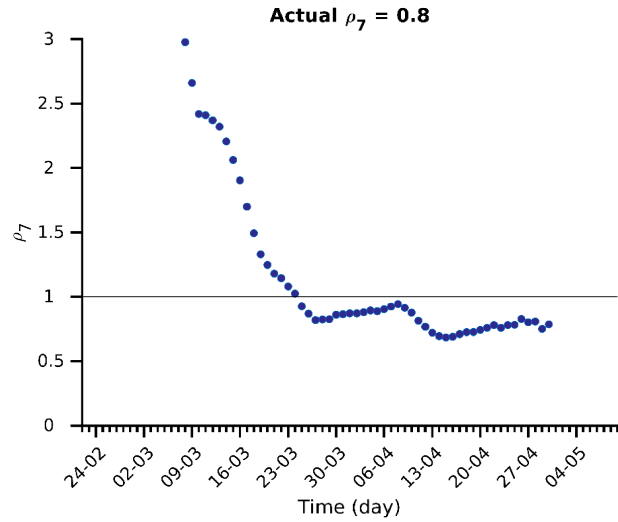
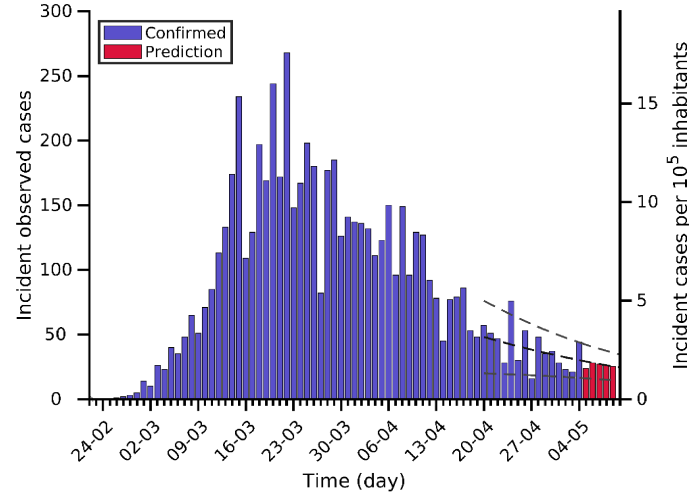
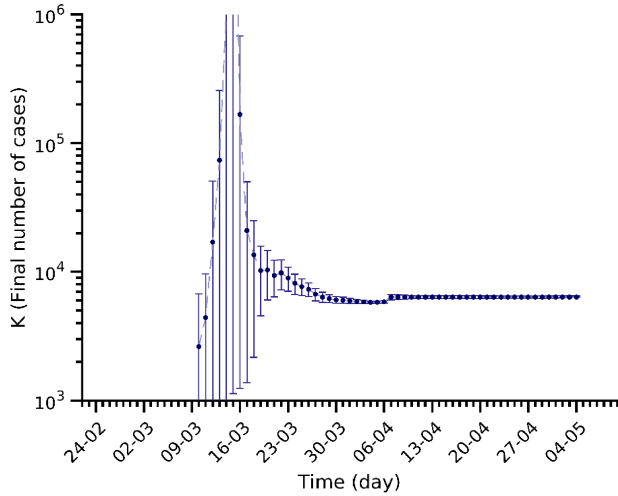
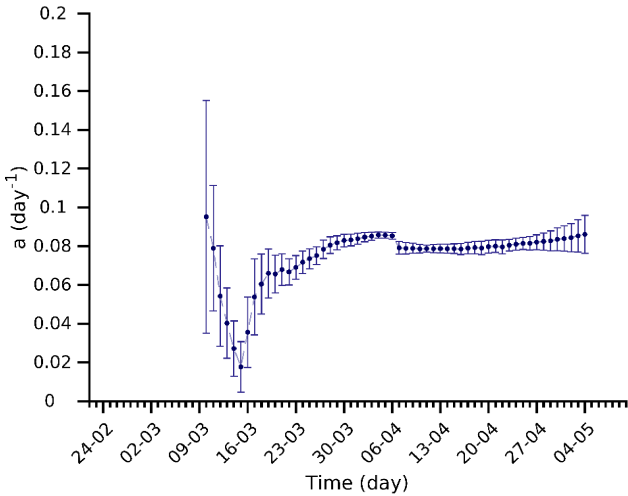
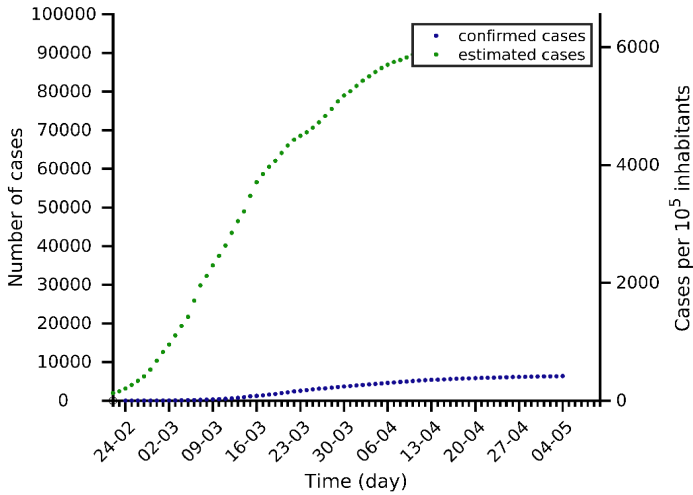
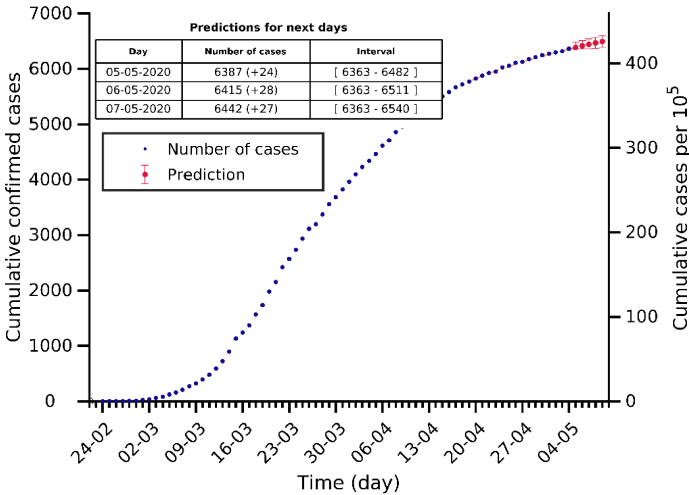
Liguria 04-05-2020. Population: 1.6M. Current cumulated incidence: 542/10⁵



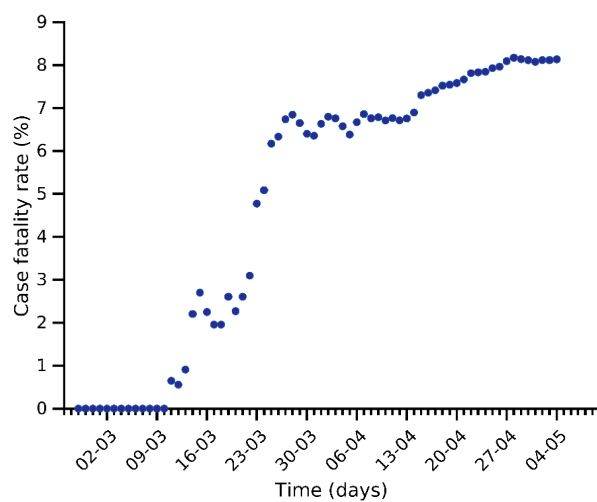
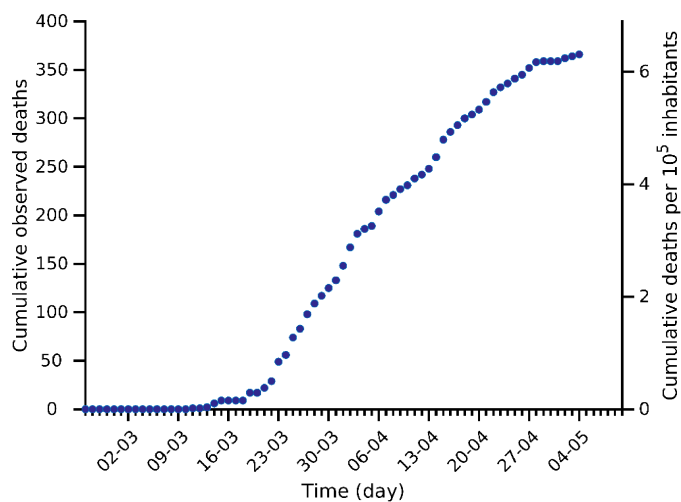
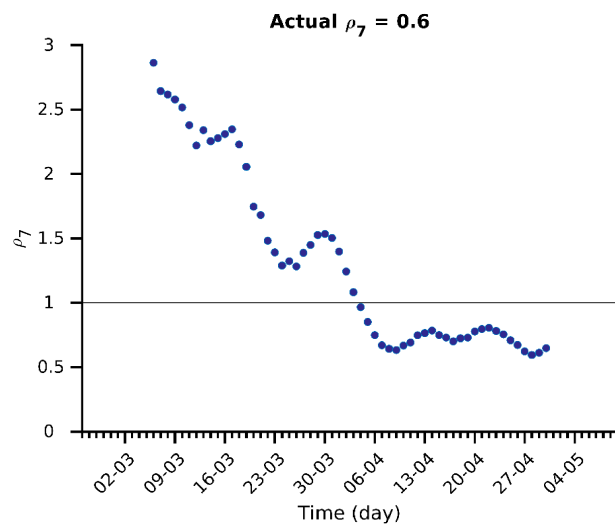
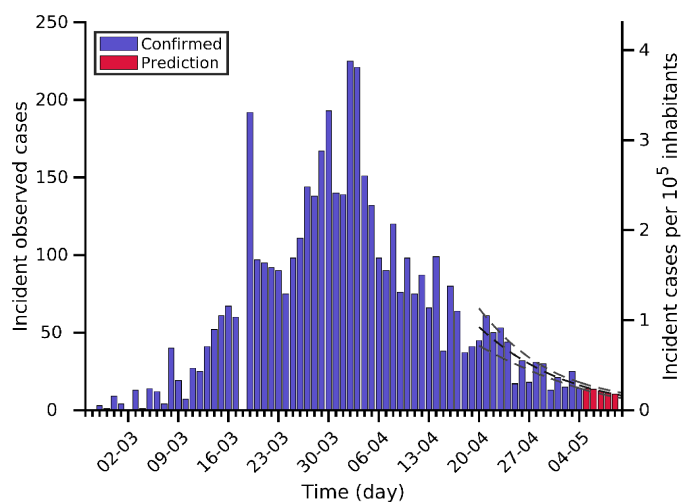
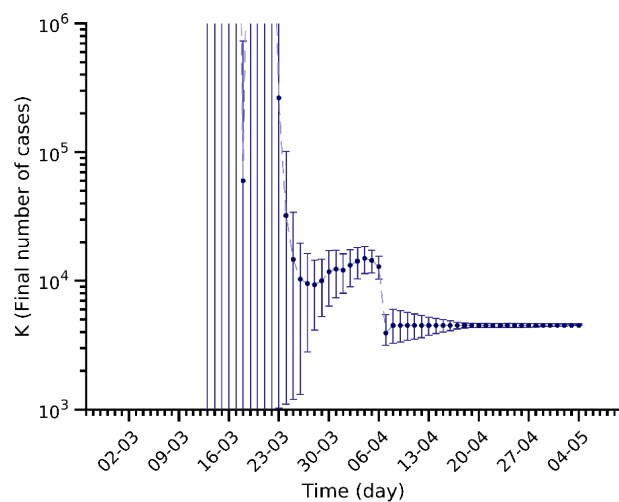
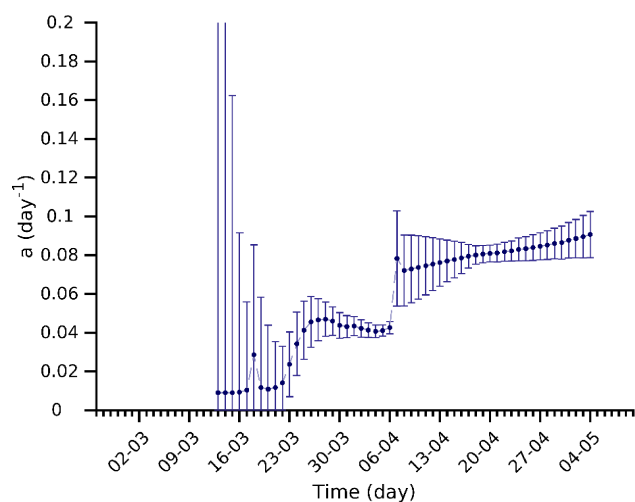
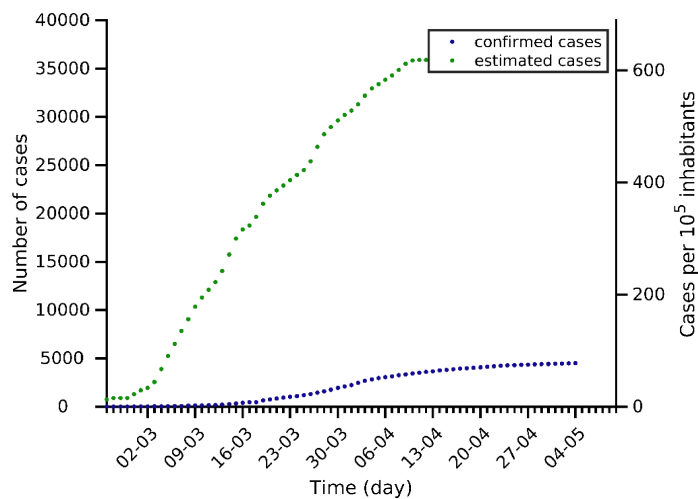
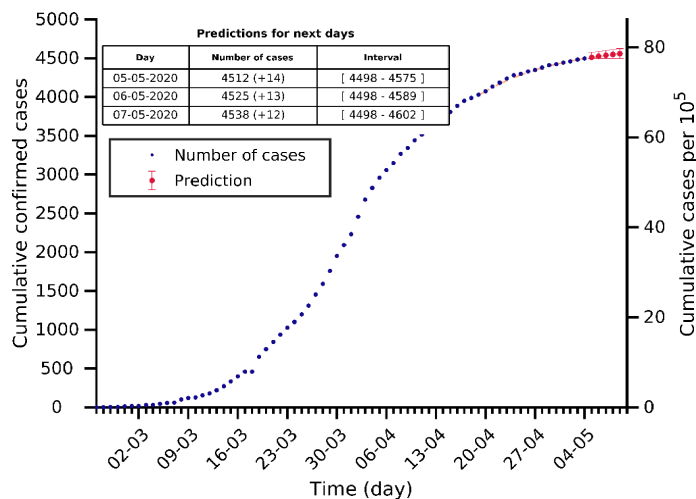
Lazio 04-05-2020. Population: 5.9M. Current cumulated incidence: 116/10⁵



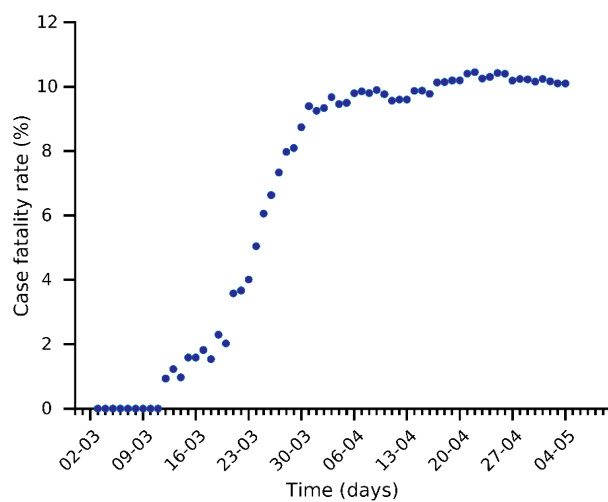
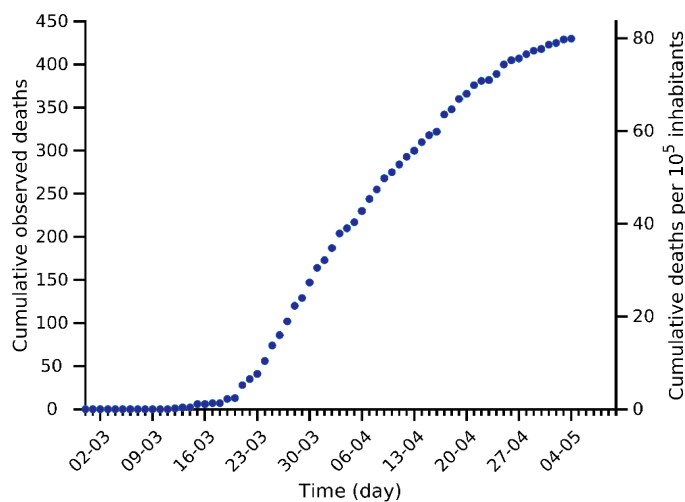
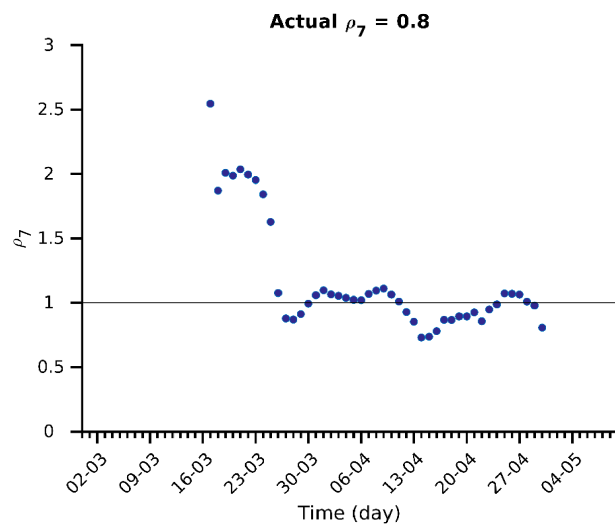
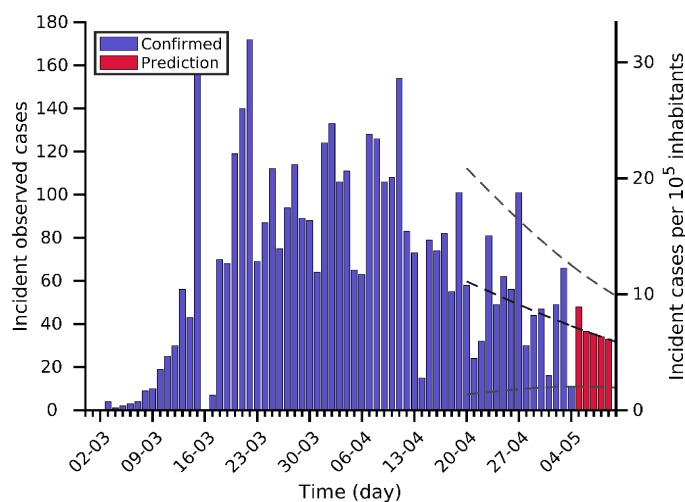
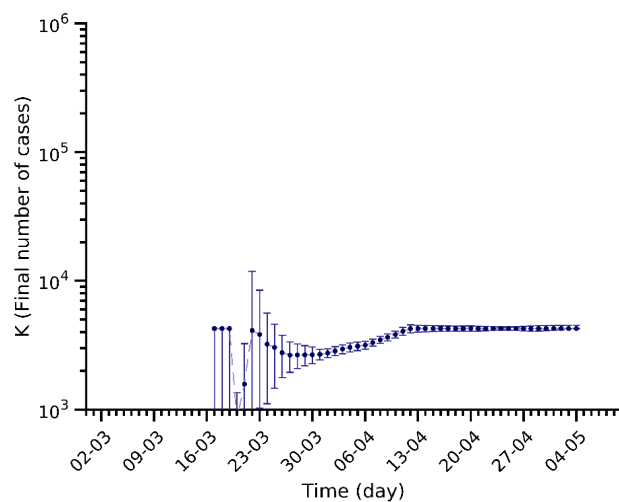
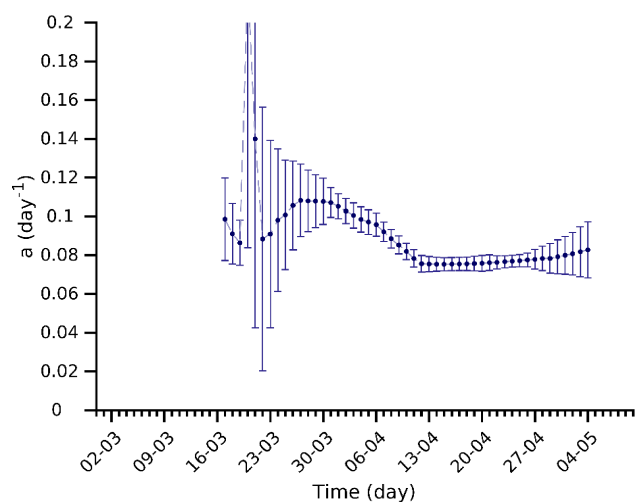
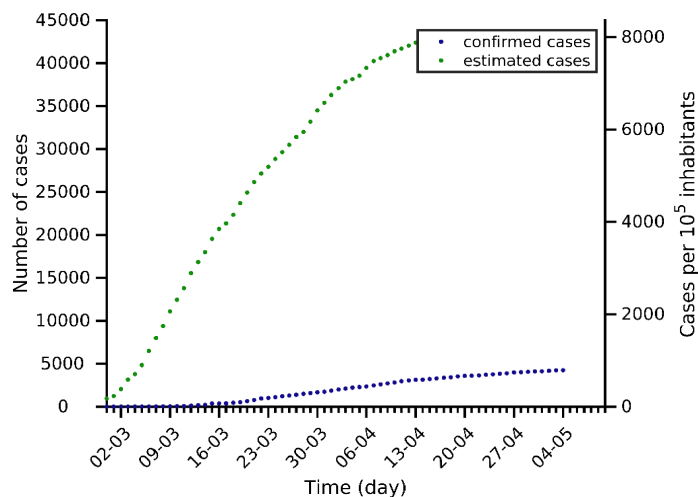
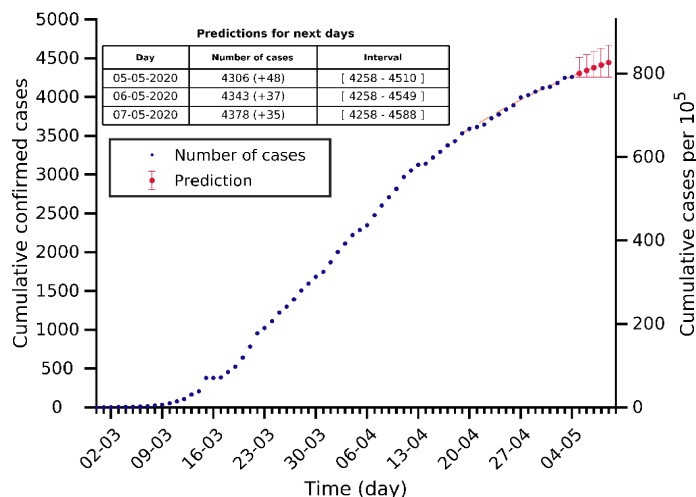
Marche
 04-05-2020.
 Population: 1.5M.
 Current cumulated incidence: 417/10⁵



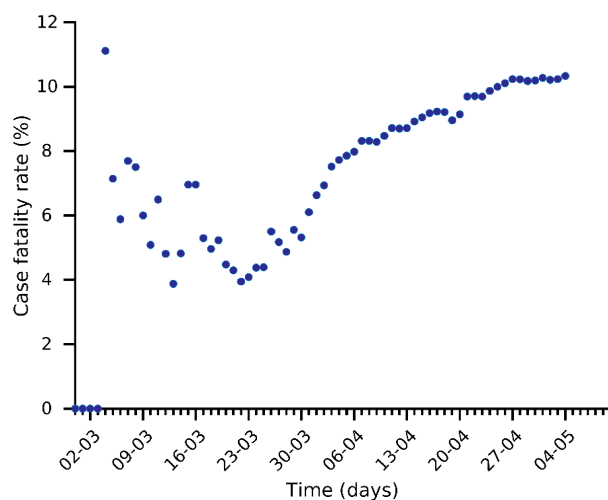
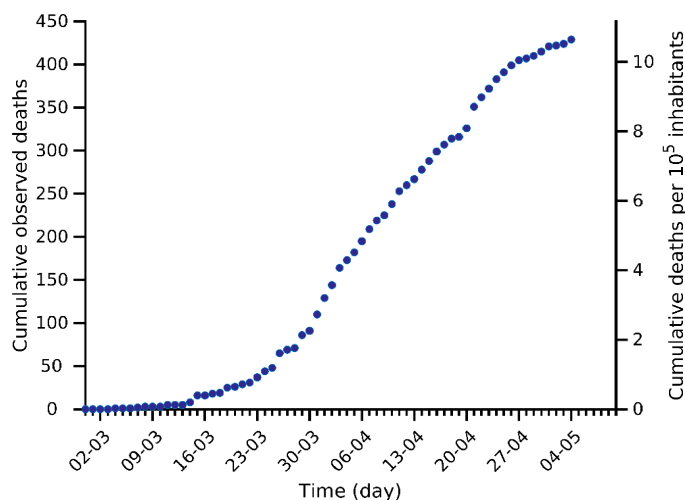
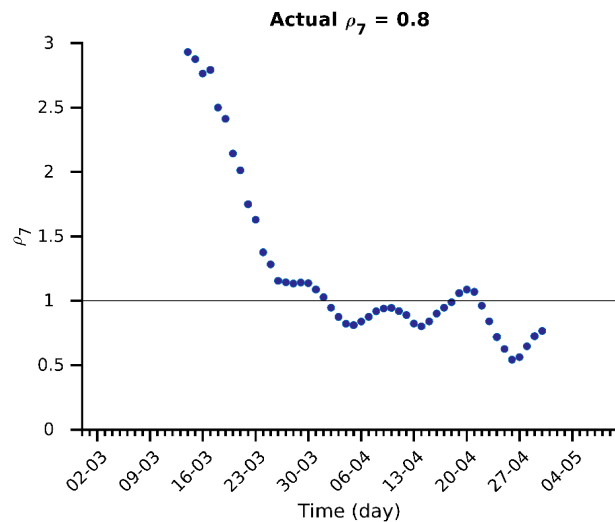
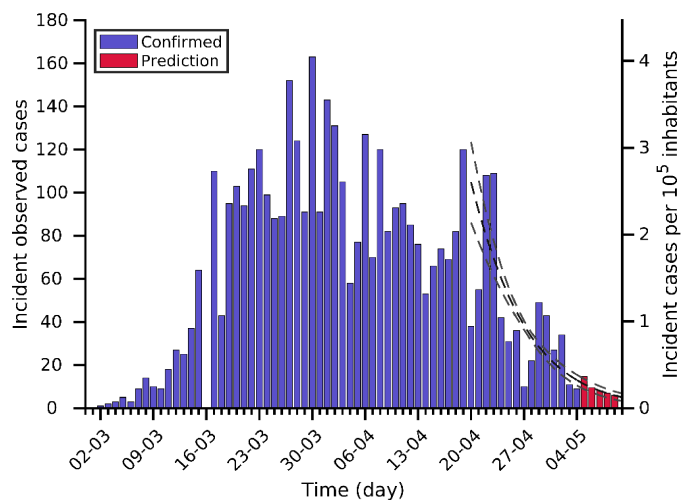
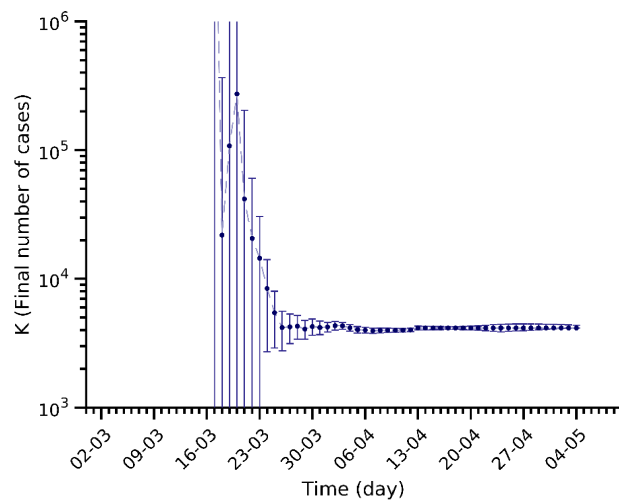
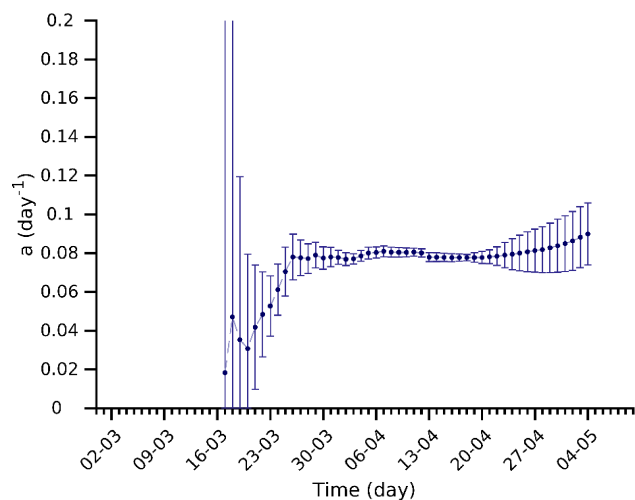
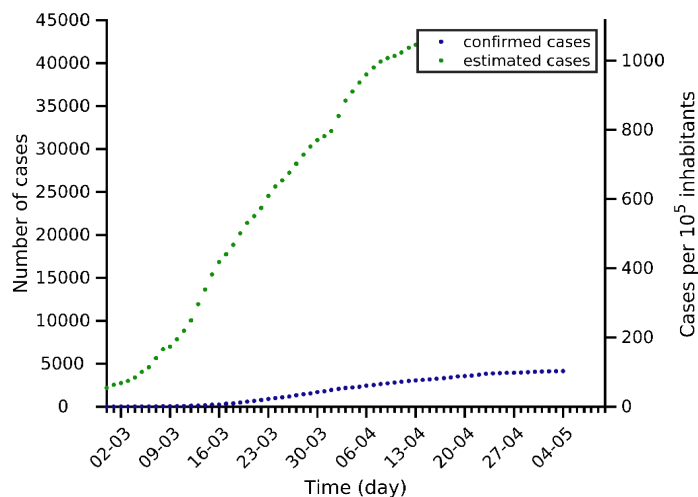
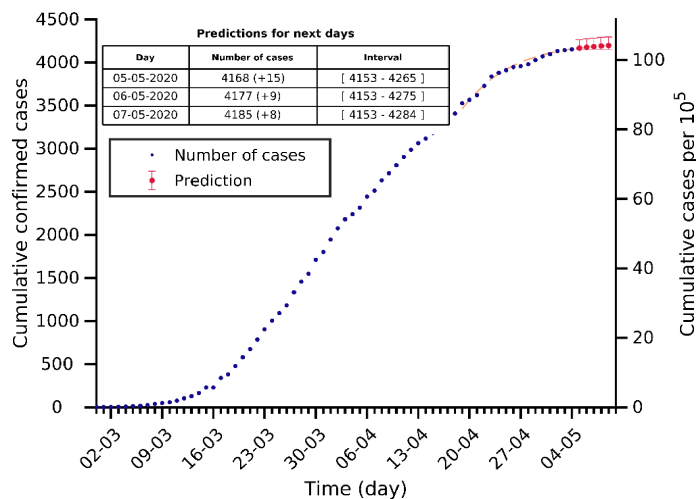
Campania 04-05-2020. Population: 5.8M. Current cumulated incidence: 78/10⁵



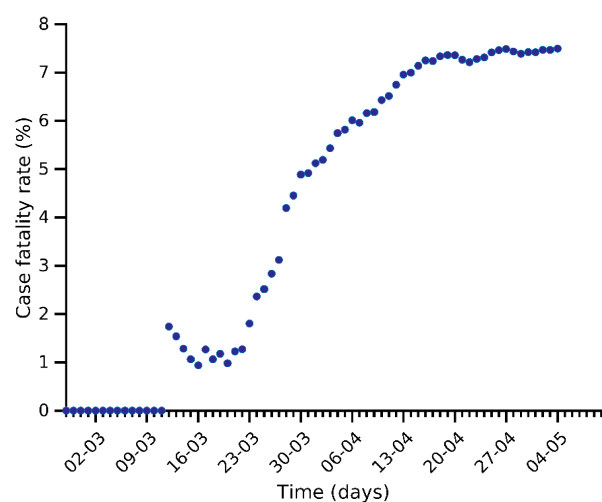
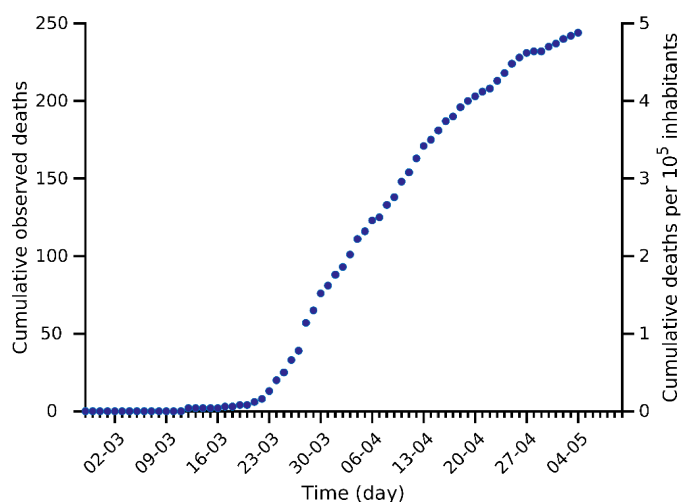
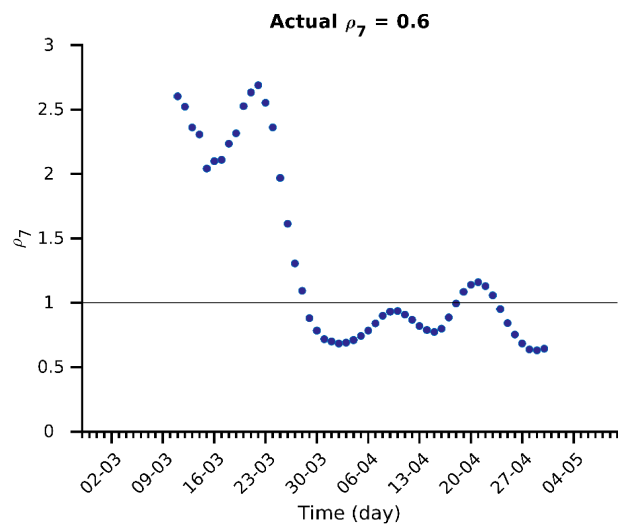
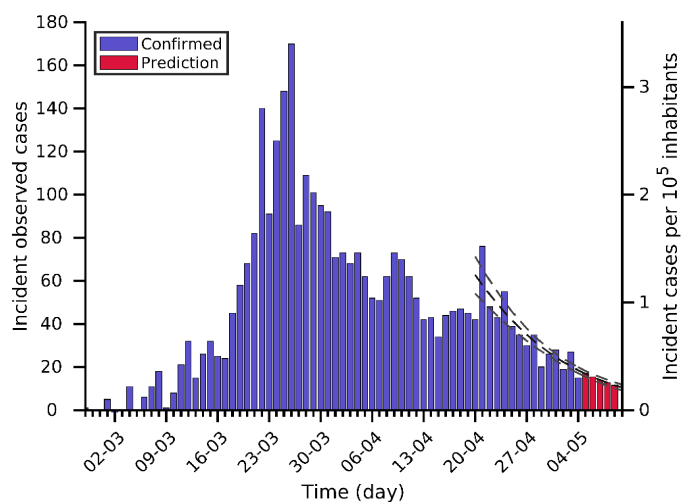
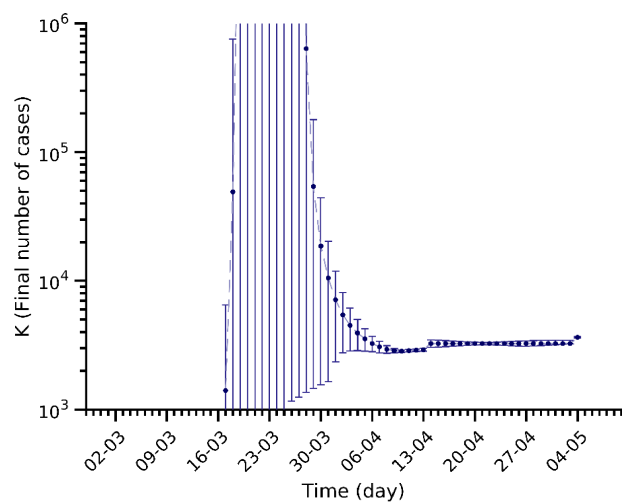
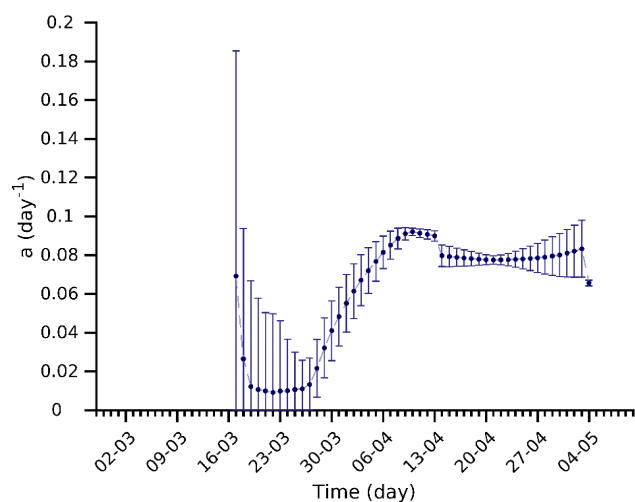
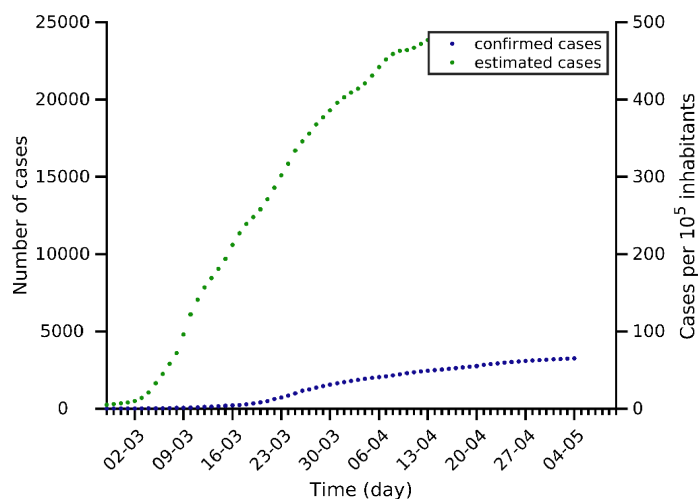
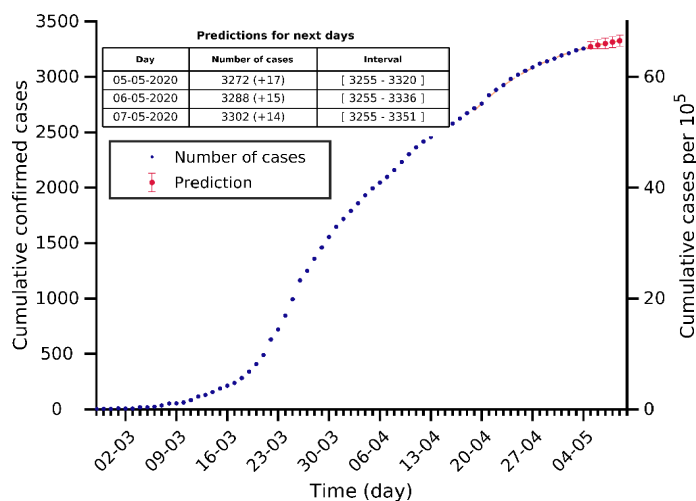
Trento 04-05-2020. Population: 0.5M. Current cumulated incidence: 791/10⁵



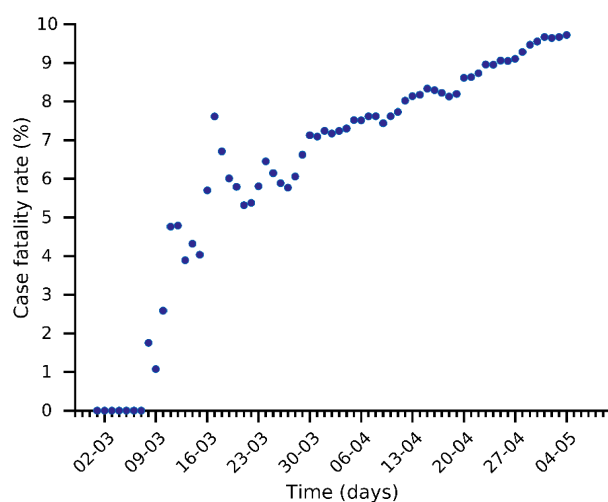
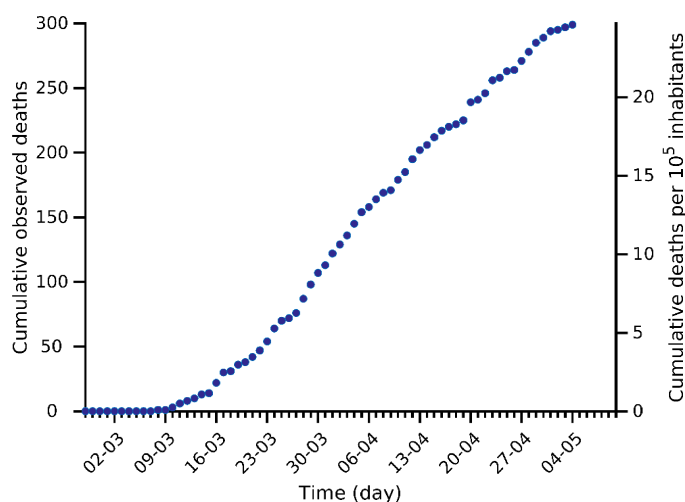
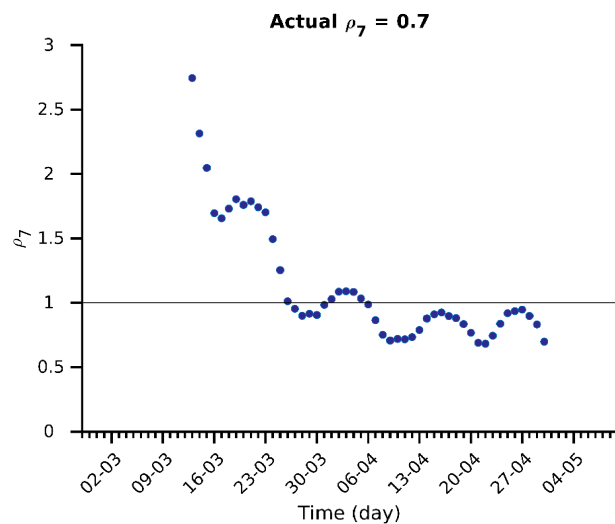
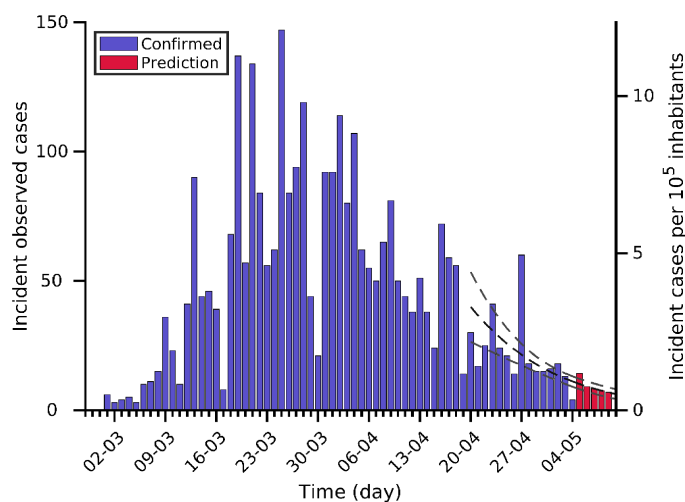
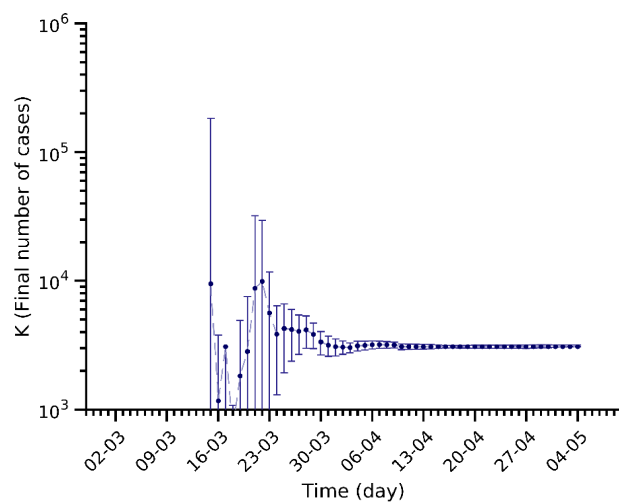
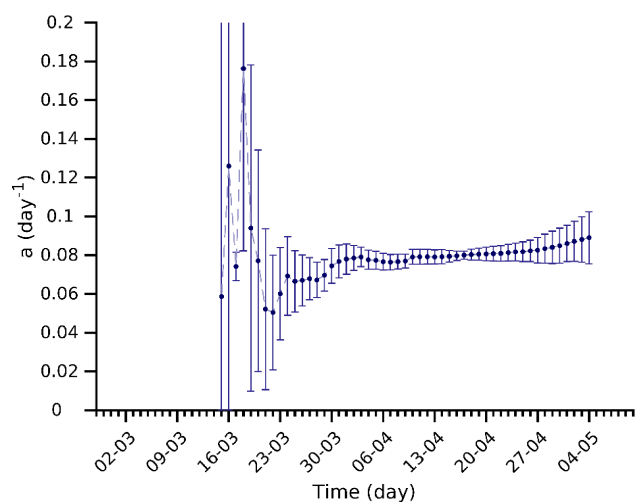
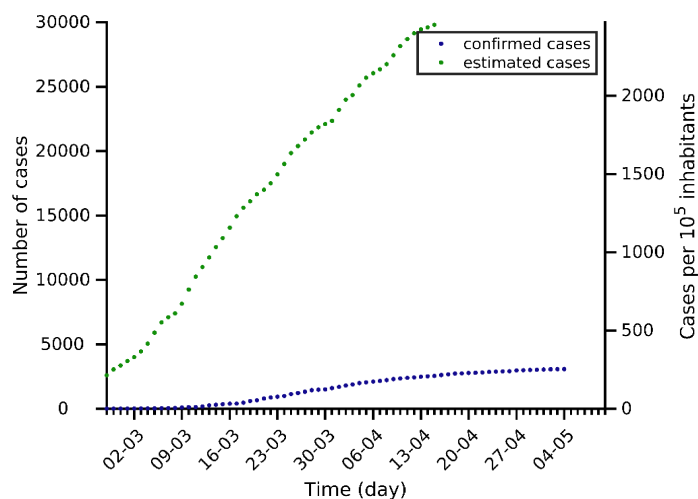
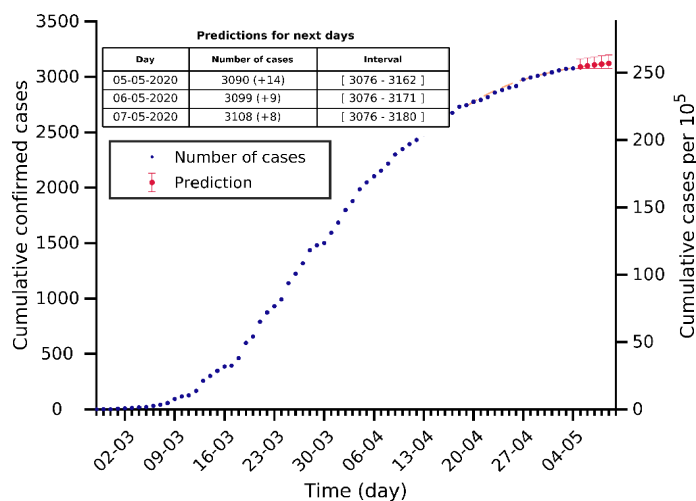
Puglia 04-05-2020. Population: 4.0M. Current cumulated incidence: 103/10⁵



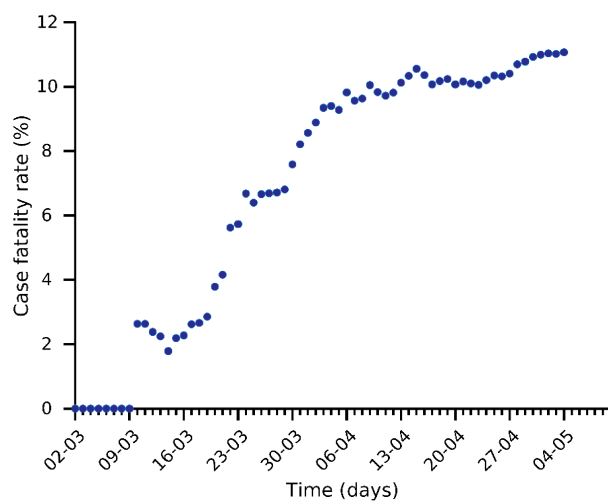
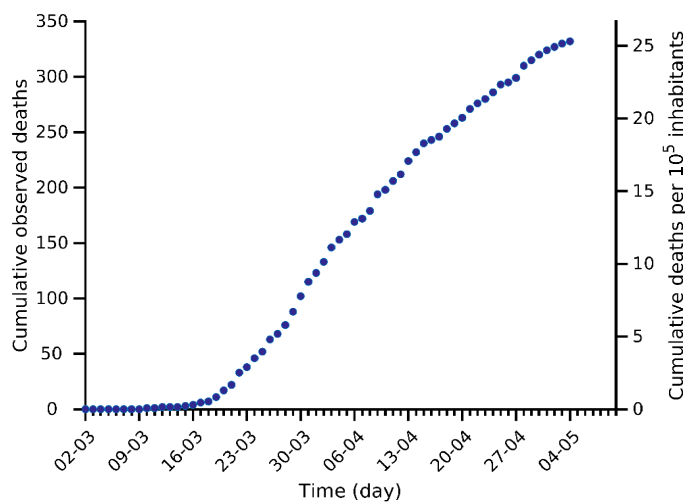
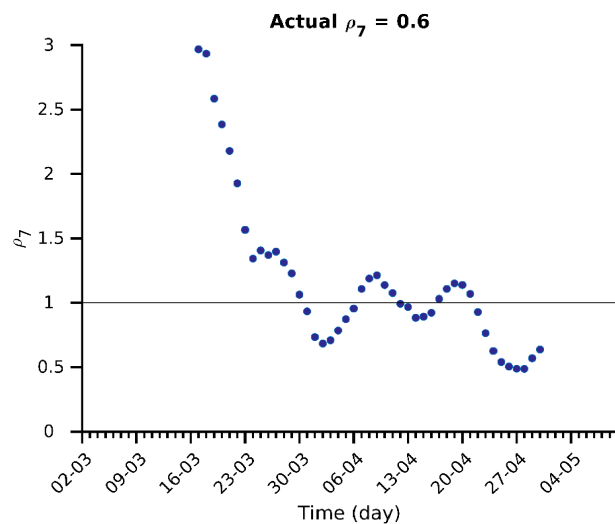
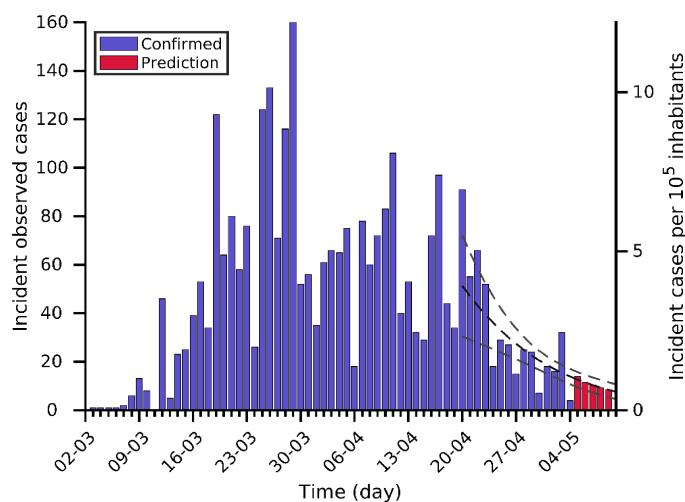
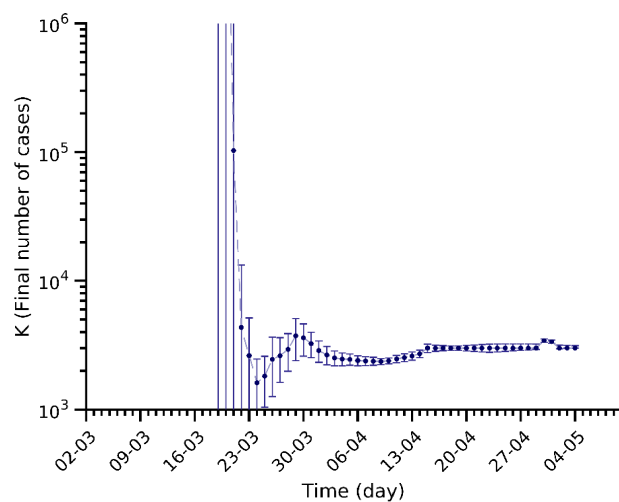
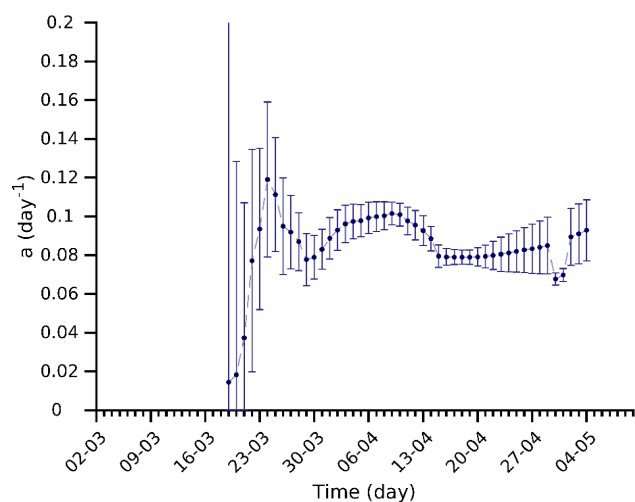
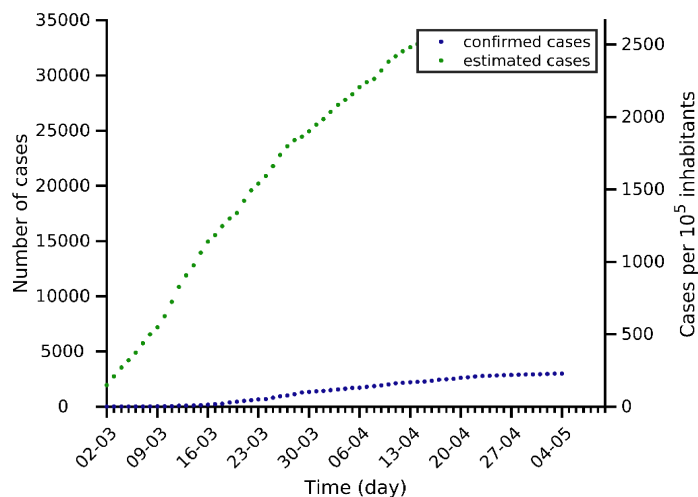
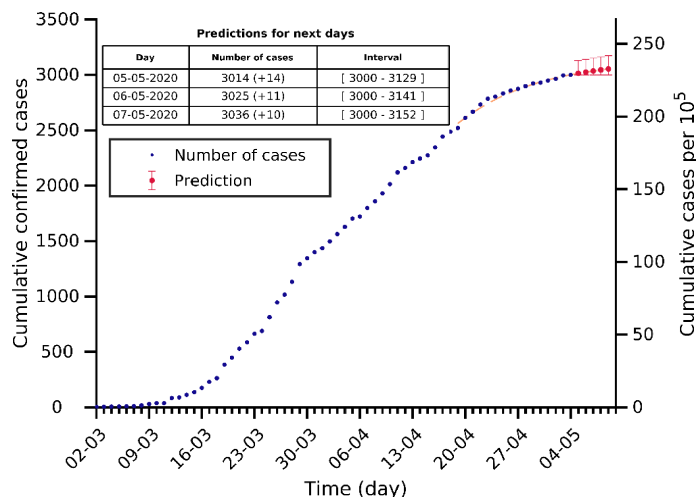
Sicilia 04-05-2020. Population: 5.0M. Current cumulated incidence: 65/10⁵



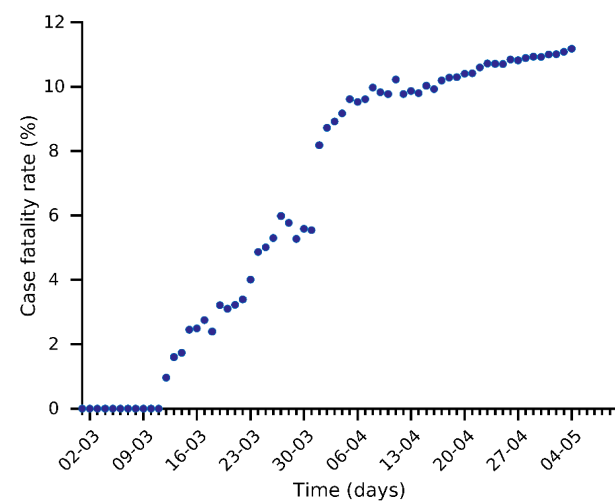
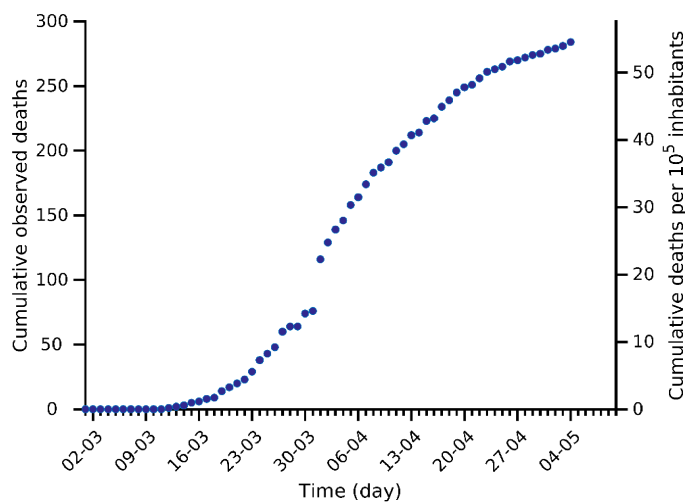
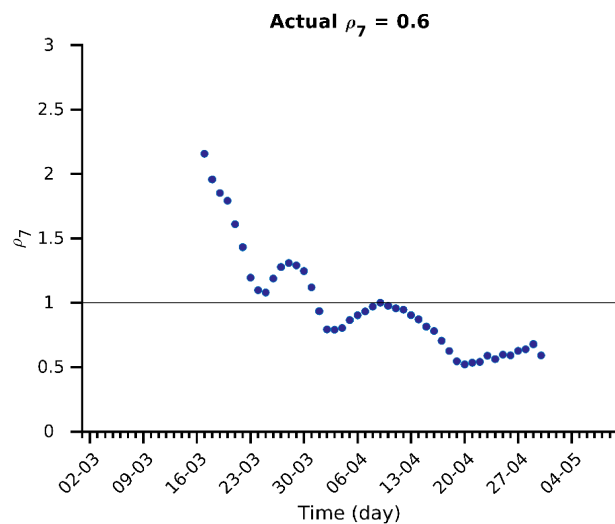
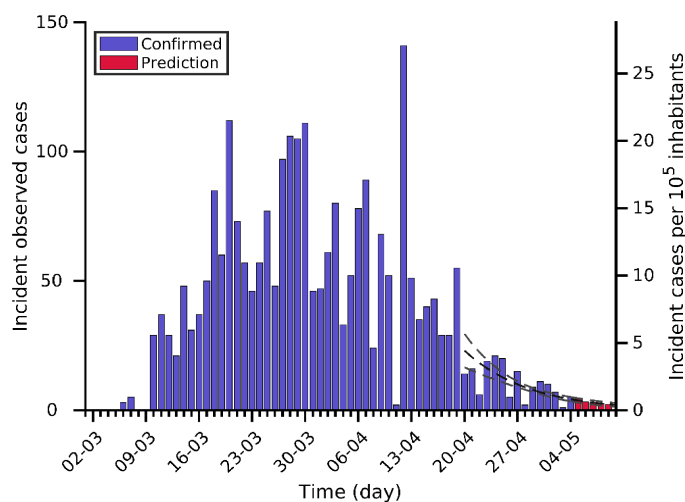
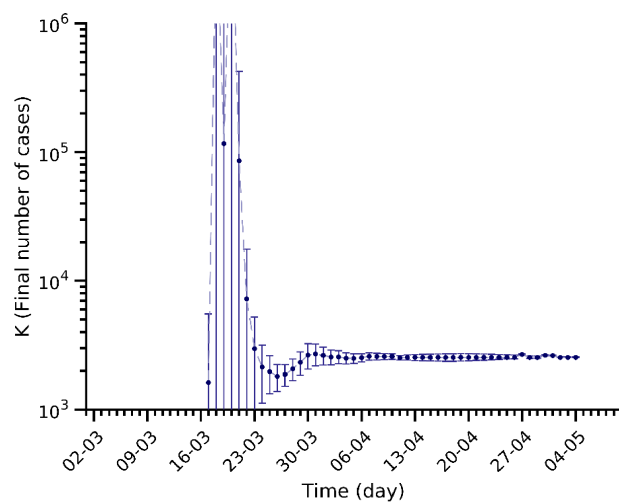
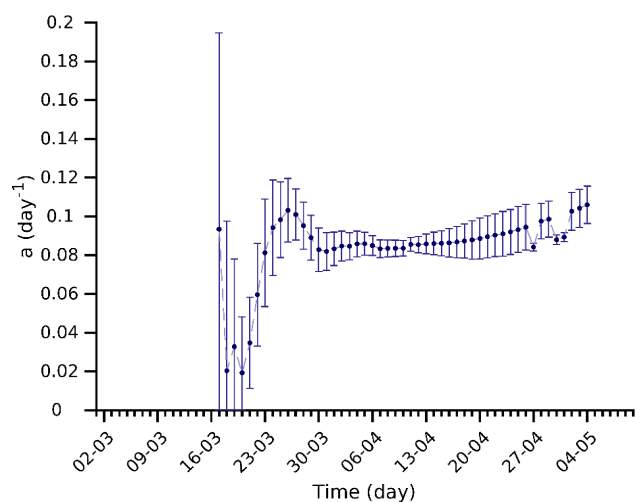
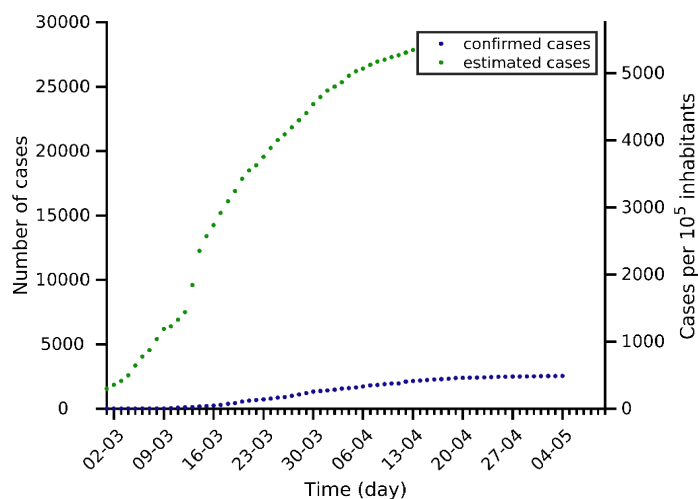
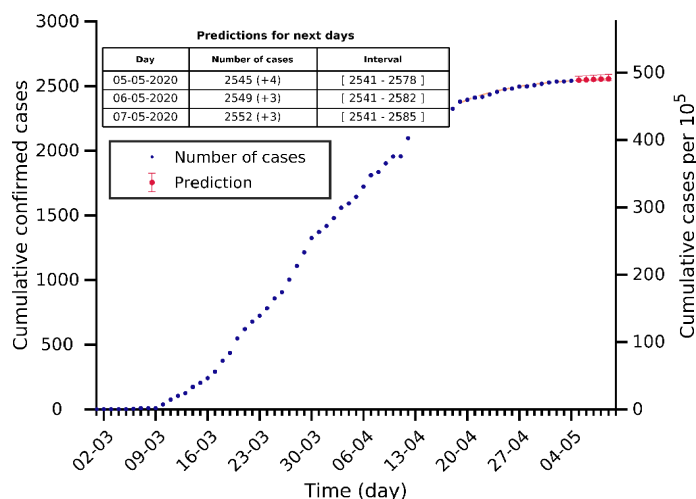
Friuli Venezia Giulia 04-05-2020. Population: 1.2M. Current cumulated incidence: 2



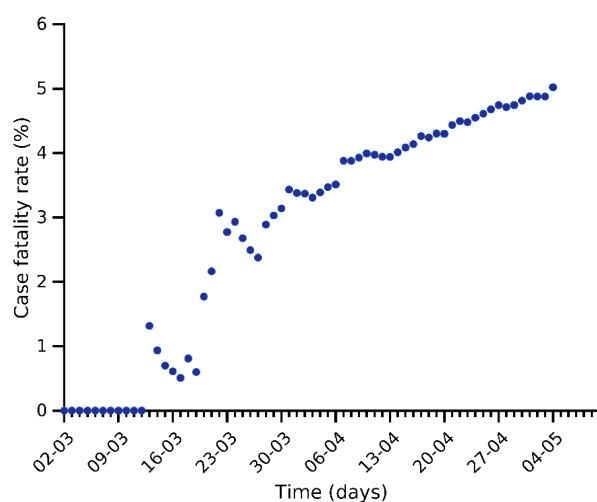
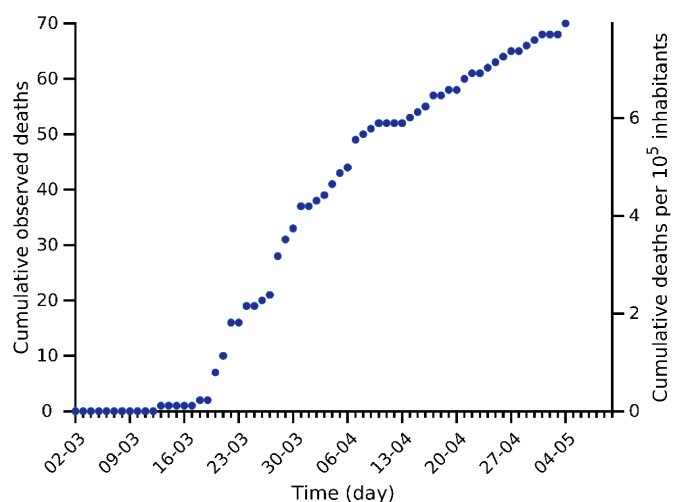
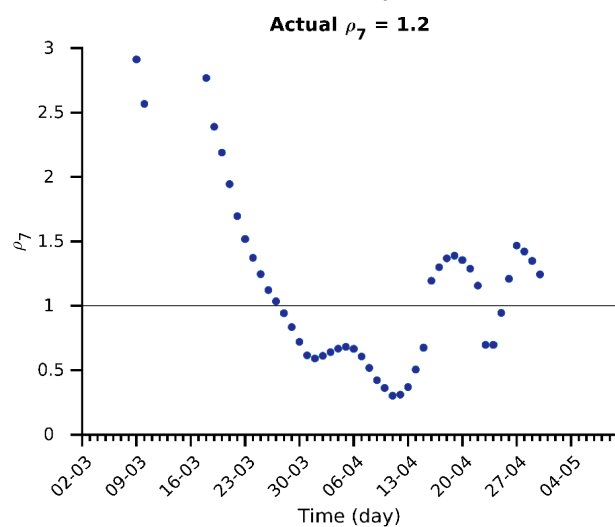
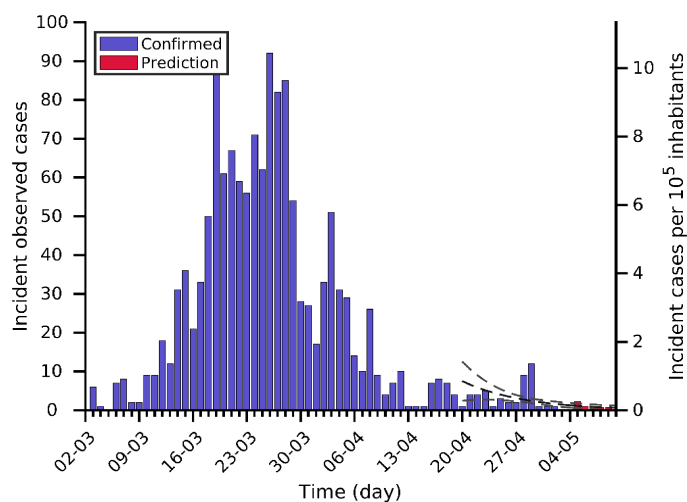
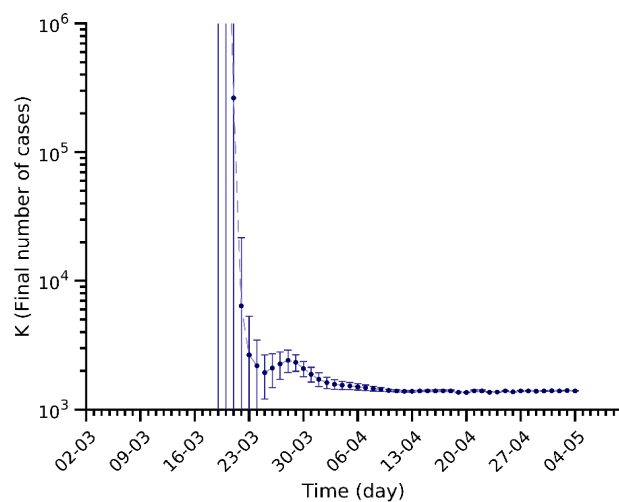
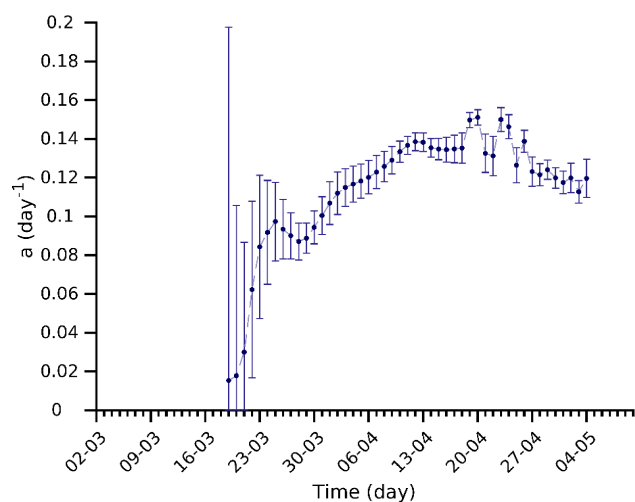
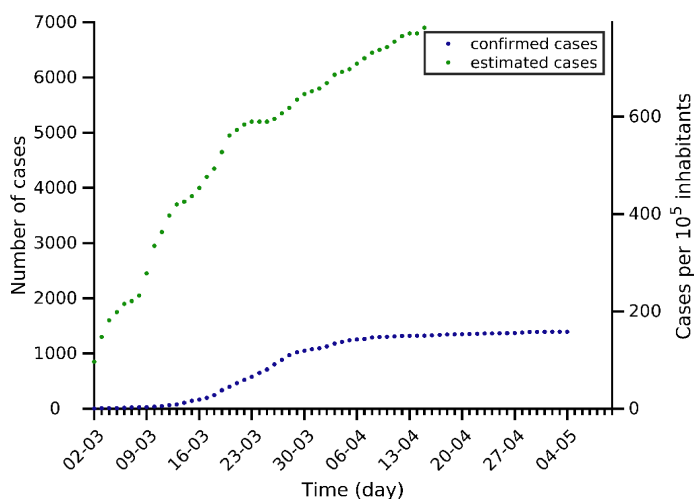
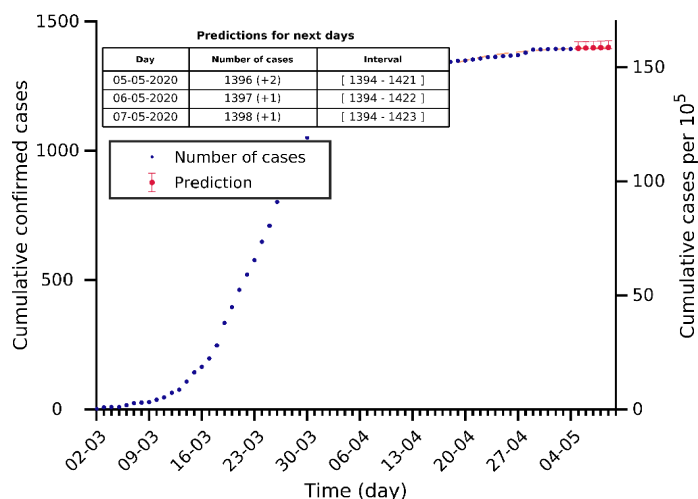
Abruzzo 04-05-2020. Population: 1.3M. Current cumulated incidence: 229/10⁵



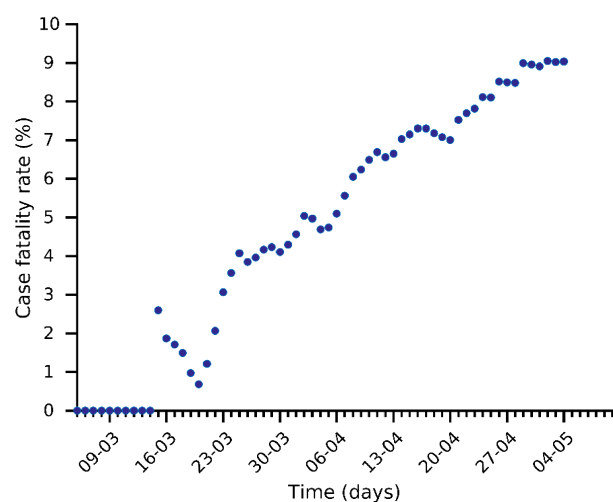
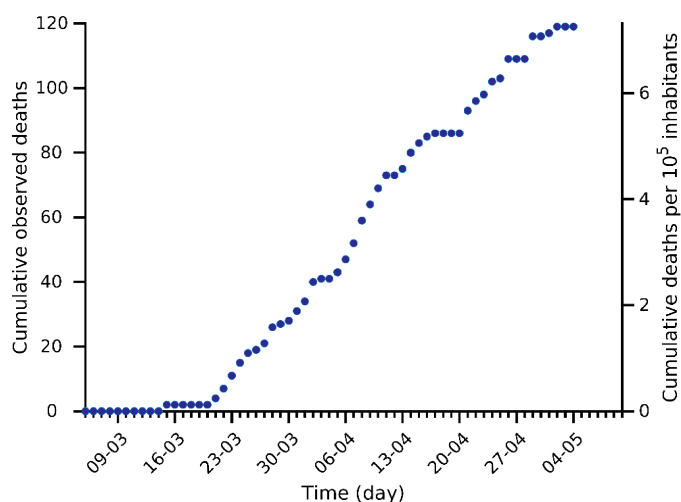
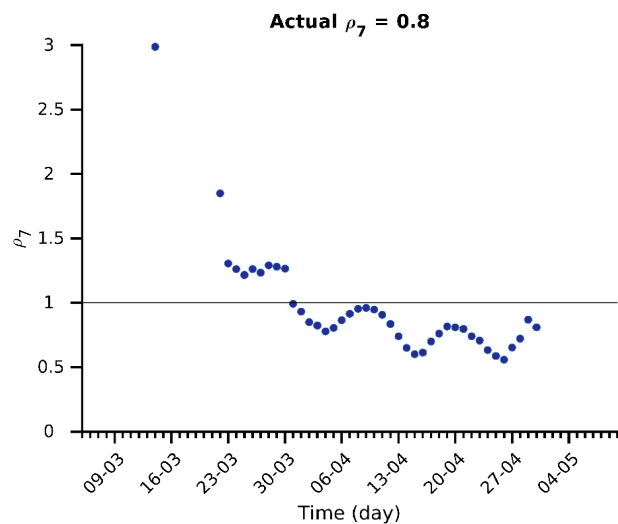
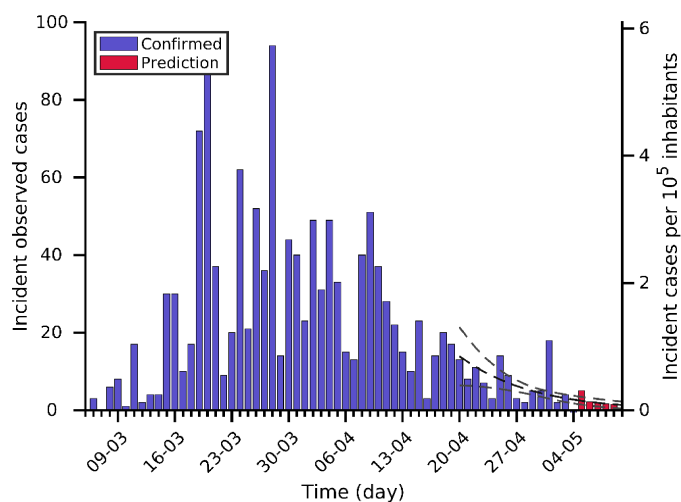
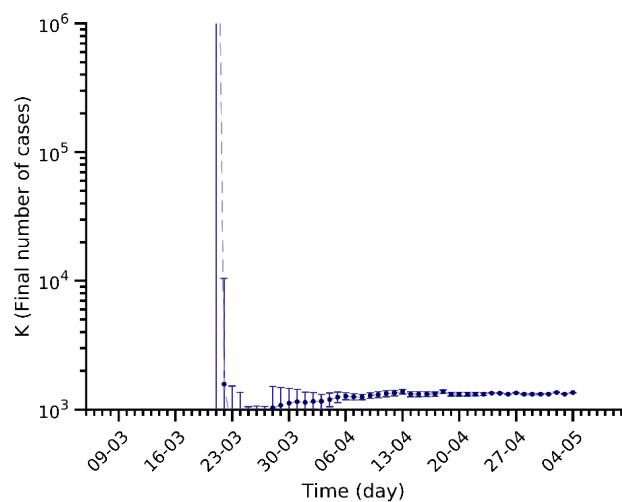
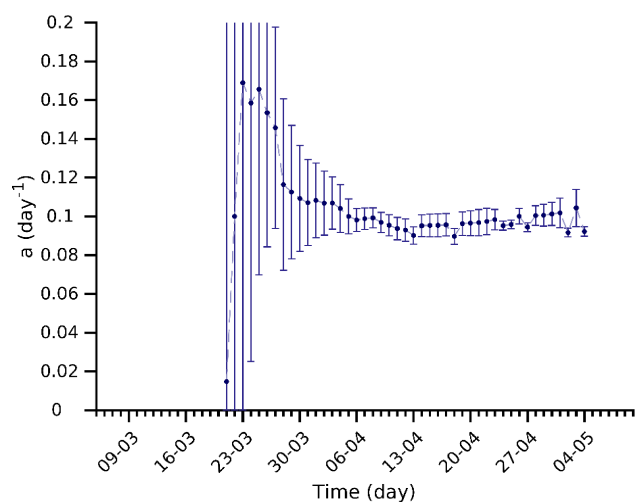
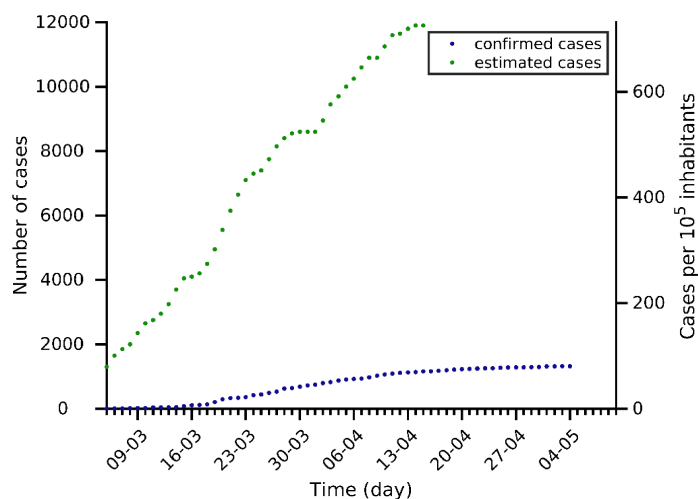
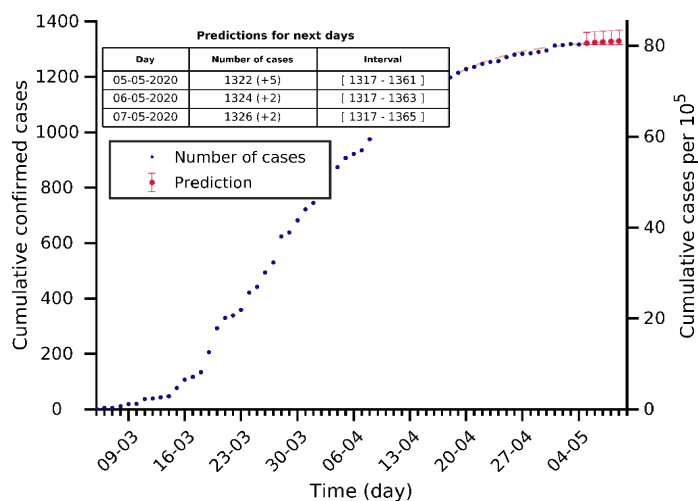
Bolzano 04-05-2020. Population: 0.5M. Current cumulated incidence: 488/10⁵



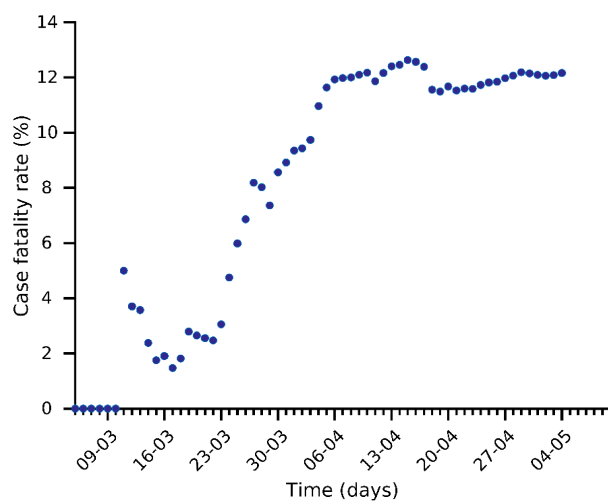
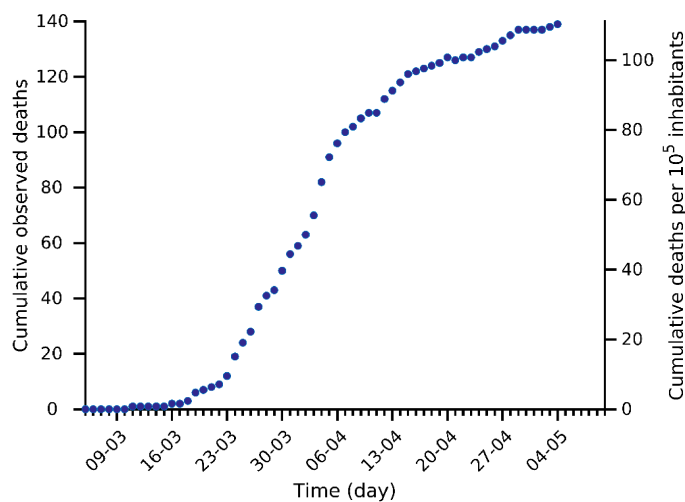
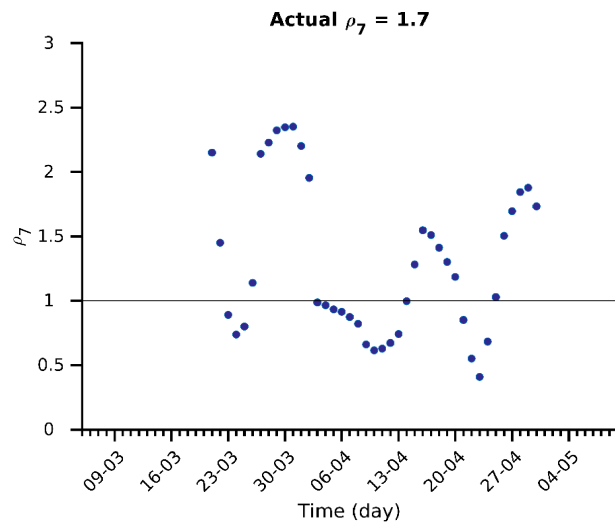
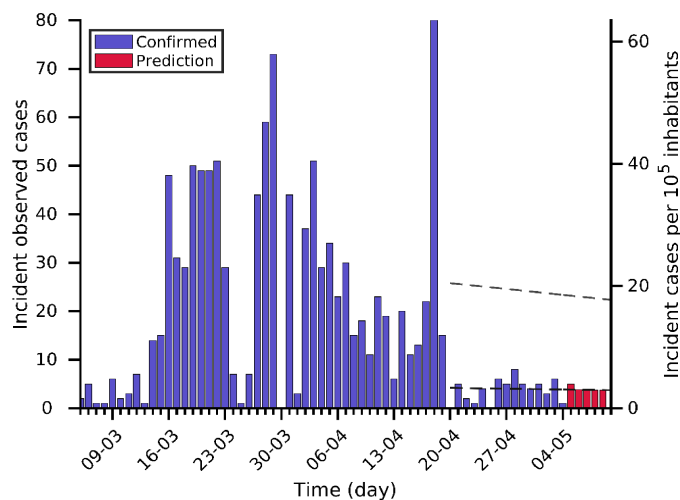
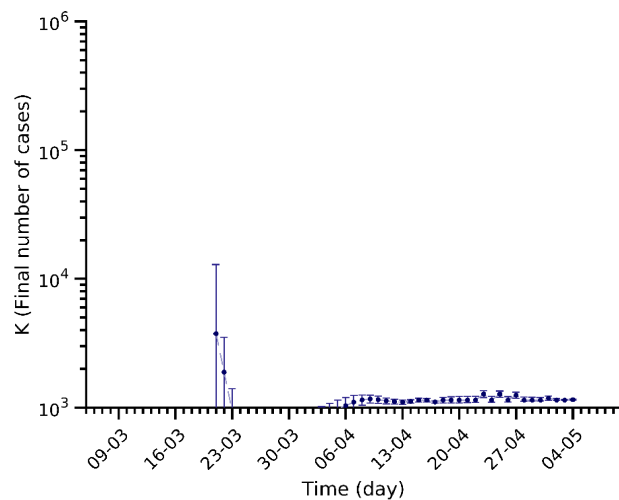
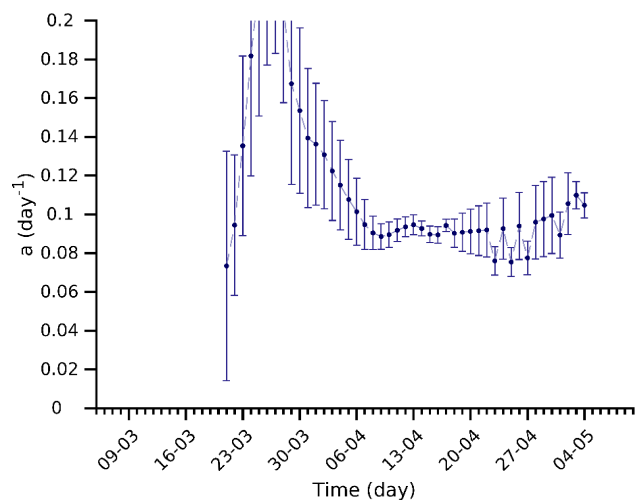
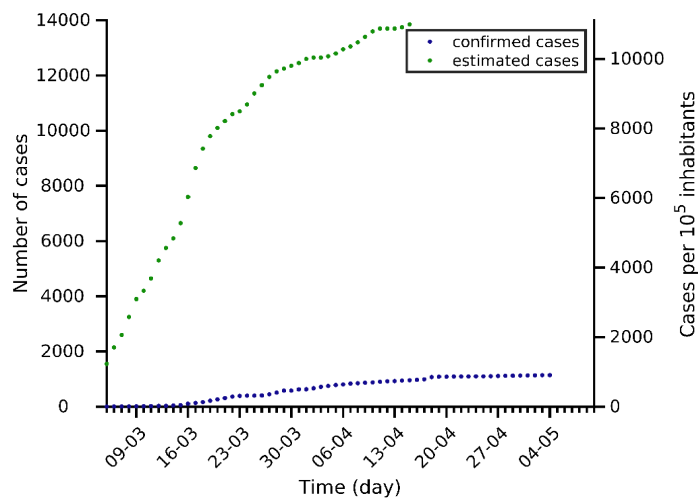
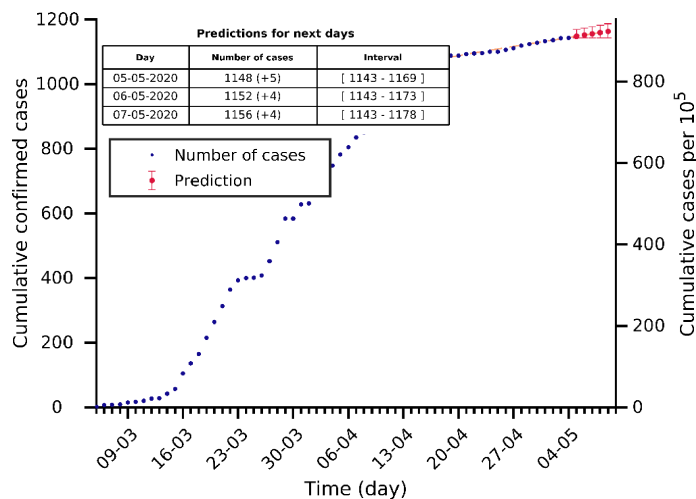
Umbria 04-05-2020. Population: 0.9M. Current cumulated incidence: 158/10⁵



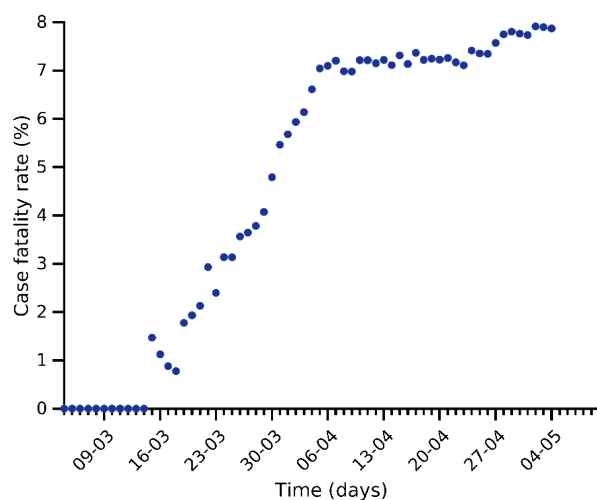
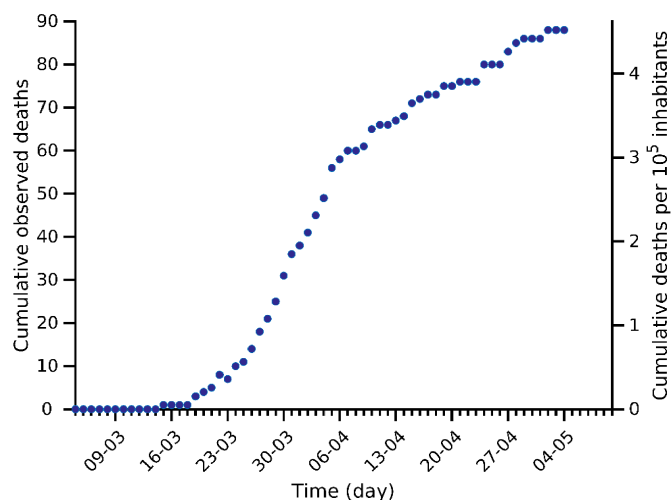
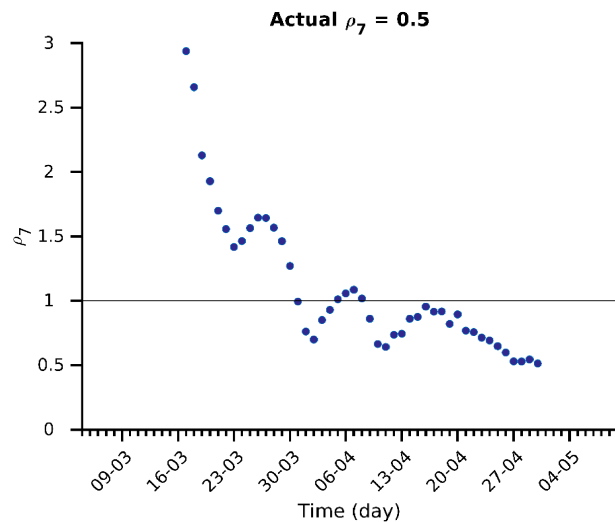
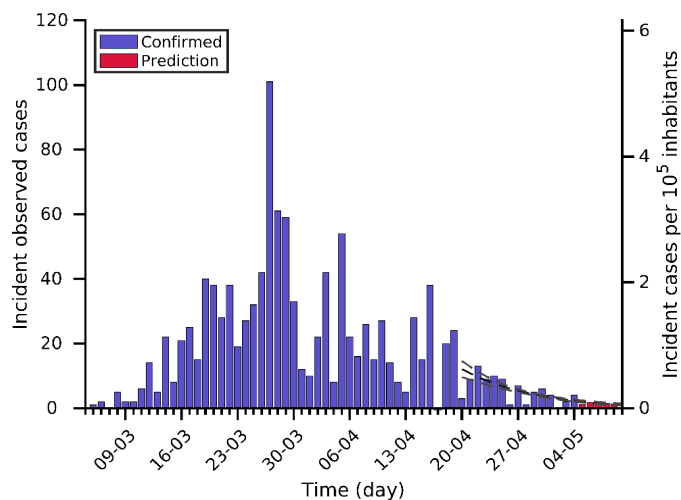
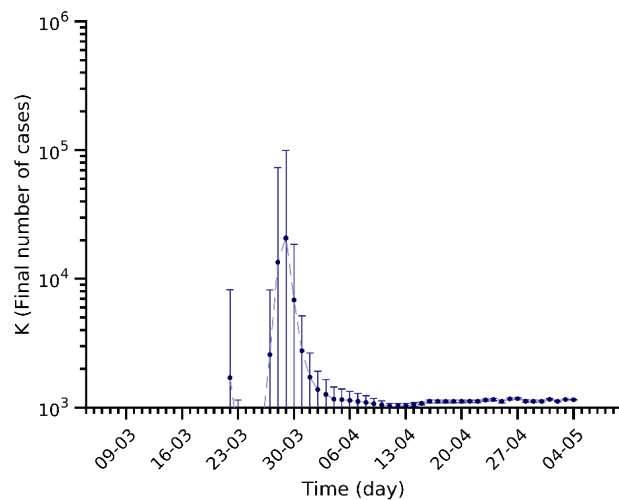
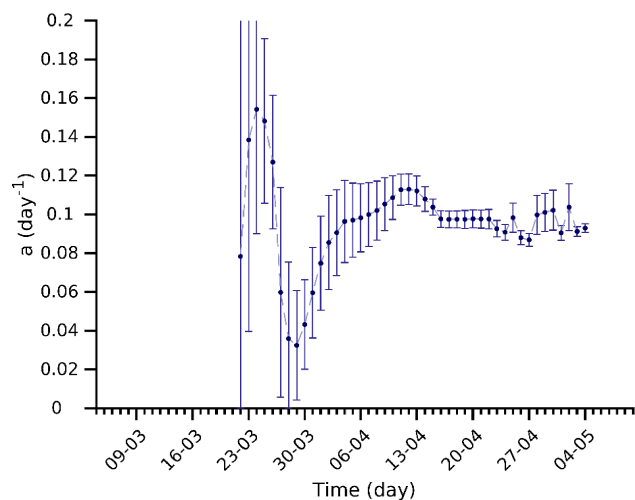
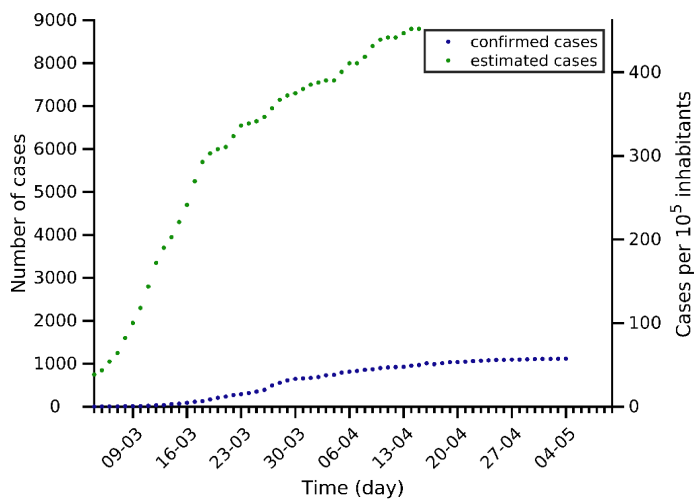
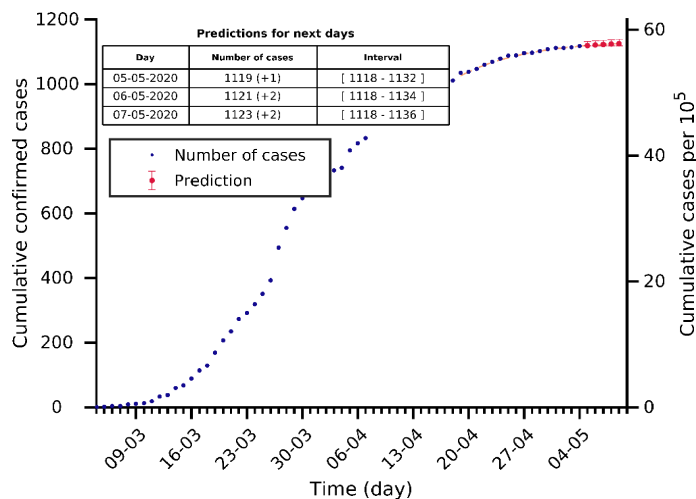
Sardegna 04-05-2020. Population: 1.6M. Current cumulated incidence: 80/10⁵



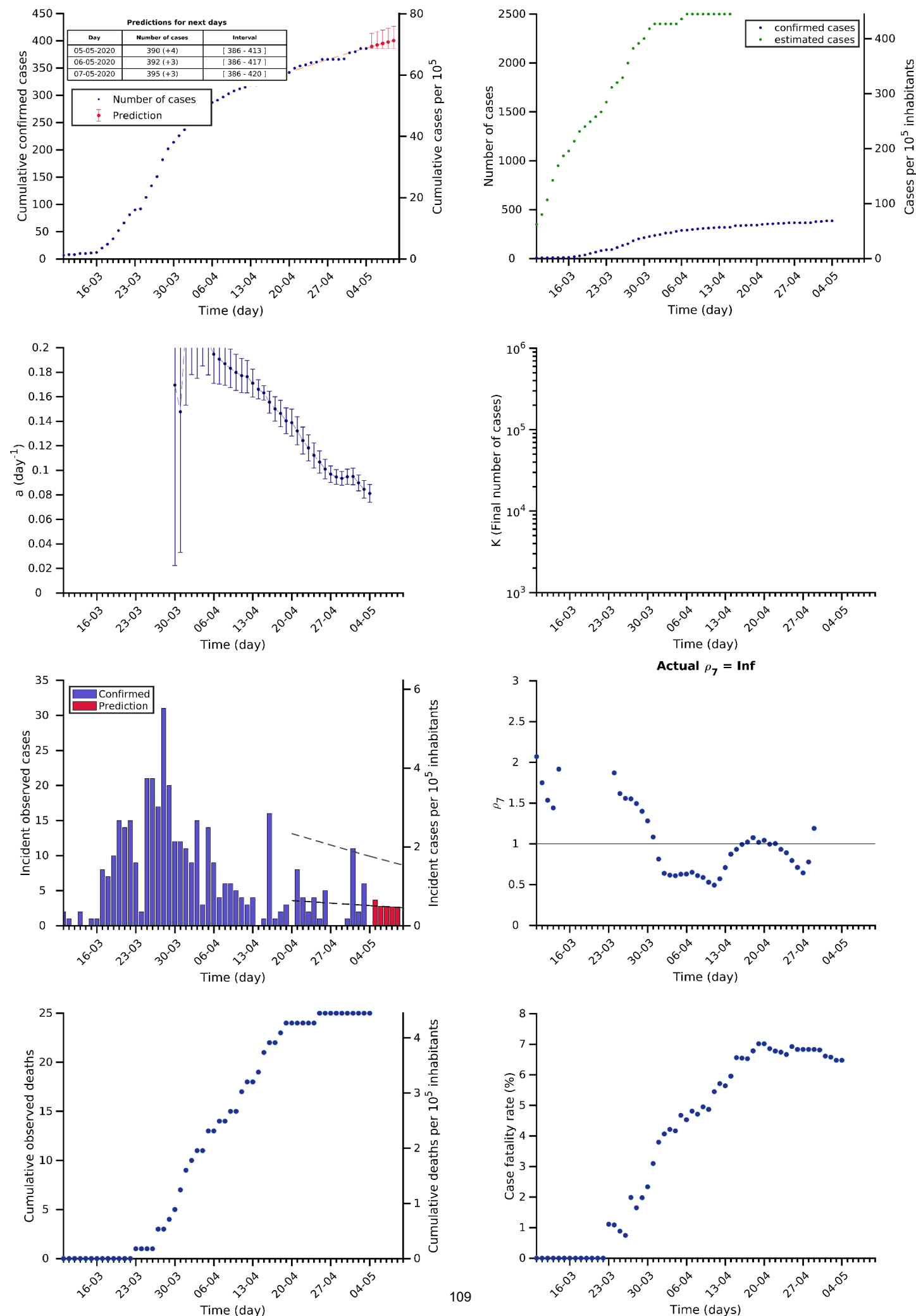
Valle d'Aosta 04-05-2020. Population: 0.1M. Current cumulated incidence: 907/10⁵



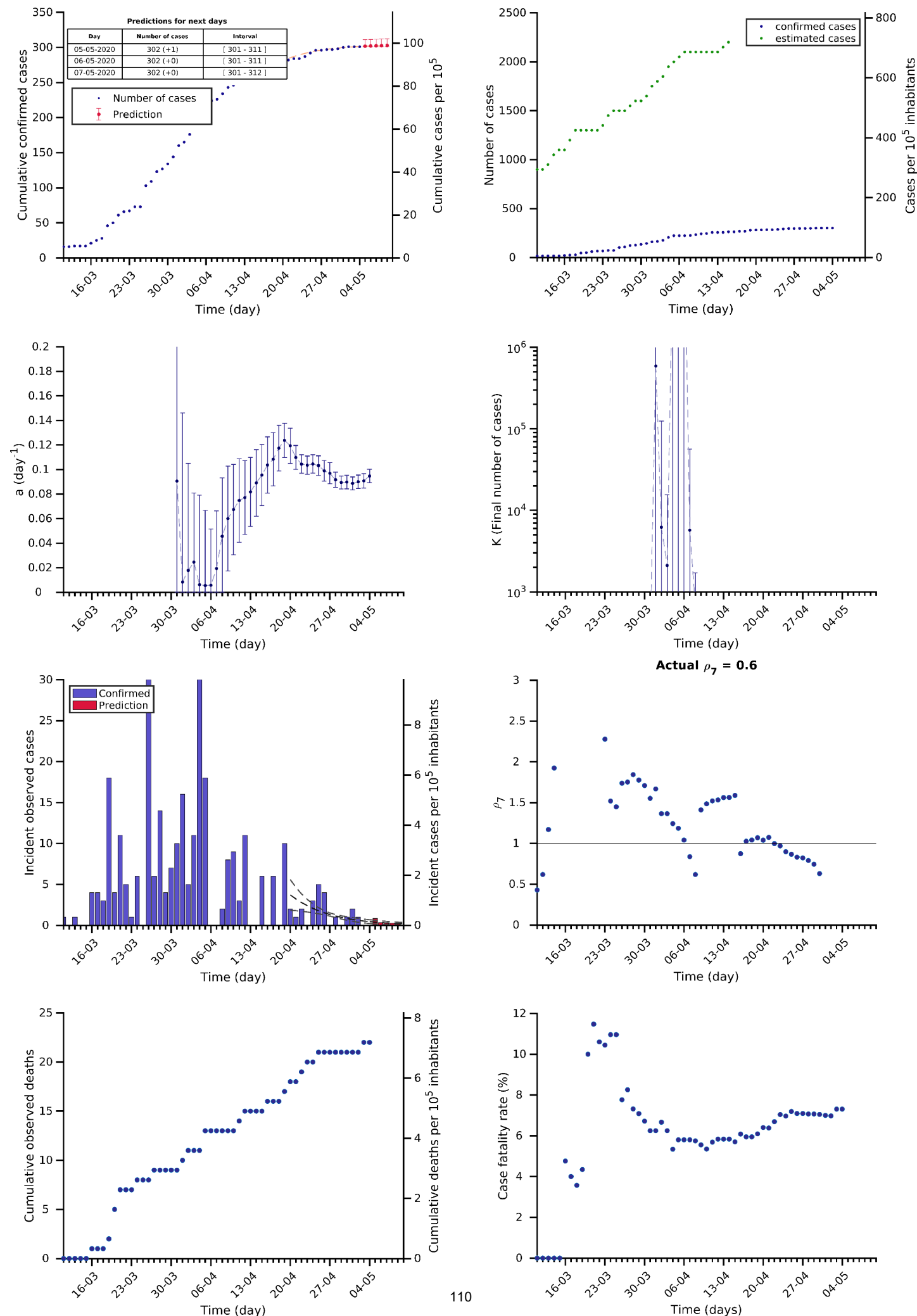
Calabria 04-05-2020. Population: 1.9M. Current cumulated incidence: 57/10⁵



Basilicata 04-05-2020. Population: 0.6M. Current cumulated incidence: 69/10⁵



Molise 04-05-2020. Population: 0.3M. Current cumulated incidence: 98/10⁵



Methods

Methods

(1) Data source

Data are daily obtained from World Health Organization (WHO) surveillance reports¹, from European Centre for Disease Prevention and Control (ECDC)² and from Ministerio de Sanidad³. These reports are converted into text files that can be processed for subsequent analysis. Daily data comprise, among others: total confirmed cases, total confirmed new cases, total deaths, total new deaths. It must be considered that the report is always providing data from previous day. In the document we use the date at which the datapoint is assumed to belong, i.e., report from 15/03/2020 is giving data from 14/03/2020, the latter being used in the subsequent analysis.

(2) Data processing and plotting

Data are initially processed with Matlab in order to update timeseries, i.e., last datapoints are added to historical sequences. These timeseries are plotted for EU individual countries and for the UE as a whole:

- ✓ Number of cumulated confirmed cases, in blue dots
- ✓ Number of reported new cases
- ✓ Number of cumulated deaths

Then, two indicators are calculated and plotted, too:

- ✓ Number of cumulated deaths divided by the number of cumulated confirmed cases, and reported as a percentage; it is an indirect indicator of the diagnostic level.
- ✓ ρ : this variable is related with the reproduction number, i.e., with the number of new infections caused by a single case. It is evaluated as follows for the day before last report ($t-1$):

$$\rho(t-1) = \frac{N_{new}(t) + N_{new}(t-1) + N_{new}(t-2)}{N_{new}(t-5) + N_{new}(t-6) + N_{new}(t-7)}$$

where $N_{new}(t)$ is the number of new confirmed cases at day t .

(3) Classification of countries according to their status in the epidemic cycle

The evolution of confirmed cases shows a biphasic behaviour:

- (I) an initial period where most of the cases are imported;
- (II) a subsequent period where most of new cases occur because of local transmission.

Once in the stage II, mathematical models can be used to track evolutions and predict tendencies. Focusing on countries that are on stage II, we classify them in three groups:

- Group A: countries that have reported more than 100 cumulated cases for 10 consecutive days or more;
- Group B: countries that have reported more than 100 cumulated cases for 7 to 9 consecutive days;
- Group C: countries that have reported more than 100 cumulated cases for 4 to 6 days.

¹ <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports>

² <https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases>

³ <https://www.msbs.gob.es/profesionales/saludPublica/ccayes/alertasActual/nCov-China/situacionActual.htm>
<https://github.com/datadista/datasets/tree/master/COVID%2019> , <https://covid19.isciii.es/>

(4) Fitting a mathematical model to data

Previous studies have shown that Gompertz model⁴ correctly describes the Covid-19 epidemic in all analysed countries. It is an empirical model that starts with an exponential growth but that gradually decreases its specific growth rate. Therefore, it is adequate for describing an epidemic that is characterized by an initial exponential growth but a progressive decrease in spreading velocity provided that appropriate control measures are applied.

Gompertz model is described by the equation:

$$N(t) = K e^{-\ln\left(\frac{K}{N_0}\right) \cdot e^{-a \cdot (t-t_0)}}$$

where $N(t)$ is the cumulated number of confirmed cases at t (in days), and N_0 is the number of cumulated cases the day at day t_0 . The model has two parameters:

- ✓ a is the velocity at which specific spreading rate is slowing down;
- ✓ K is the expected final number of cumulated cases at the end of the epidemic.

This model is fitted to reported cumulated cases of the UE and of countries in stage II that accomplish two criteria: 4 or more consecutive days with more than 100 cumulated cases, and at least one datapoint over 200 cases. Day t_0 is chosen as that one at which $N(t)$ overpasses 100 cases. If more than 15 datapoints that accomplish the stated criteria are available, only the last 15 points are used. The fitting is done using Matlab's Curve Fitting package with Nonlinear Least Squares method, which also provides confidence intervals of fitted parameters (a and K) and the R^2 of the fitting. At the initial stages the dynamics is exponential and K cannot be correctly evaluated. In fact, at this stage the most relevant parameter is a . Fitted curves are incorporated to plots of cumulative reported cases with a dashed line. Once a new fitting is done, two plots are added to the country report:

- ✓ Evolution of fitted a with its error bars, i.e., values obtained on the fitting each day that the analysis has been carried out;
- ✓ Evolution of fitted K with its error bars, i.e., values obtained on the fitting each day that the analysis has been carried out; if lower error bar indicates a value that is lower than current number of cases, the error bar is truncated.

These plots illustrate the increase in fittings' confidence, as fitted values progressively stabilize around a certain value and error bars get smaller when the number of datapoints increases. In fact, in the case of countries, they are discarded and set as "Not enough data" if $a > 0.2 \text{ day}^{-1}$, if $K > 10^6$ or if the error in K overpasses 10^6 .

It is worth to mention that the simplicity of this model and the lack of previous assumptions about the Covid-19 behaviour make it appropriate for universal use, i.e., it can be fitted to any country independently of its socioeconomic context and control strategy. Then, the model is capable of quantifying the observed dynamics in an objective and standard manner and predicting short-term tendencies.

(5) Using the model for predicting short-term tendencies

The model is finally used for a short-term prediction of the evolution of the cumulated number of cases. The predictions increase their reliability with the number of datapoints used in the fitting. Therefore, we consider three levels of prediction, depending on the country:

⁴ Madden LV. Quantification of disease progression. *Protection Ecology* 1980; **2**: 159-176.

- Group A: prediction of expected cumulated cases for the following 3-5 days⁵;
- Group B: prediction of expected cumulated cases for the following 2 days;
- Group C: prediction of expected cumulated cases for the following day.

The confidence interval of predictions is assessed with the Matlab function `predint`, with a 99% confidence level. These predictions are shown in the plots as red dots with corresponding error bars, and also gathered in the attached table. For series longer than 9 timepoints, last 3 points are weighted in the fitting so that changes in tendencies are well captured by the model.

(6) Estimating non-diagnosed cases

Lethality of Covid-19 has been estimated at around 1 % for Republic of Korea and the Diamond Princess cruise. Besides, median duration of viral shedding after Covid-19 onset has been estimated at 18.5 days for non-survivors⁶ in a retrospective study in Wuhan. These data allow for an estimation of total number of cases, considering that the number of deaths at certain moment should be about 1 % of total cases 18.5 days before. This is valid for estimating cases of countries at stage II, since in stage I the deaths would be mostly due to the incidence at the country from which they were imported. We establish a threshold of 50 reported cases before starting this estimation.

Reported deaths are passed through a moving average filter of 5 points in order to smooth tendencies. Then, the corresponding number of cases is found assuming the 1 % lethality. Finally, these cases are distributed between 18 and 19 days before each one.

⁵ At this moment we are testing predictions at 4 days for countries with more than 100 cumulated cases for 13-15 consecutive days, and 5 days for 16 or more days.

⁶ Zhou et al., 2020. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. The Lancet; March 9, doi: 10.1016/S0140-6736(20)30566-3